NEW SPECIES OF *HEMICYCLOPS* (COPEPODA, CYCLOPOIDA) FROM MADAGASCAR

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INTRODUCTION

One species of the genus *Hemicyclops*, *H. visendus* Humes, Cressey, and Gooding, 1958, is already known from Madagascar. This copepod lives at Nosy Bé in association with the thalassinidean shrimp *Upogebia* (*Upogebia*) sp., having been recovered by washing the bodies of the crustaceans in sea water with a small amount of ethyl alcohol.

As a result of extensive collecting in the region of Nosy Bé during 1960 and 1963–64, seven more species of *Hemicyclops* have been found, all of them new. Two of the species came from burrows known to be inhabited by a shrimp, one was washed from the body of a stomatopod, and the remaining four were recovered from water drawn from intertidal burrows of unknown origin by means of a small hand-operated bilge pump.

The island of Nosy Bé lies a few miles off the northwestern coast of Madagascar and is intersected by Lat. 13°20′S and Long. 48°15′E. (The map presented by Humes, 1962, p. 39, shows a French geographic grid based on a circle of 400°, with the longitude relative to the Paris meridian, instead of the more conventional degrees of latitude and longitude.) The spelling "Nosy Bé" (nosy = island, and bé = large, in Malgache) is the preferred form, although "Nossi Bé" is sometimes used.

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I wish also to thank Dr. Fenner A. Chace, Jr., for the identification of the thalassinidean and Dr. Raymond B. Manning for the generic name of the stomatopod.

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The material covered in this work comprises copepods from (1) burrows of the thalassinidean shrimp *Axius* (*Neaxius*) *acanthus* A. Milne Edwards:

Hemicyclops axiophilus n. sp.
Hemicyclops amplicaudatus n. sp.

(2) burrows of unknown origin:

Hemicyclops carinifer n. sp.
Hemicyclops diremptus n. sp.
Hemicyclops kombensis n. sp.
Hemicyclops biflagellatus n. sp.

(3) the body of the stomatopod crustacean *Acanthosquilla* sp.:

Hemicyclops acanthosquillae n. sp.

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SYSTEMATIC DESCRIPTION

Hemicyclops axiophilus[1] n. sp.

Pls. I–VI; VII, figs. 39–40

Type material.—276 females, 282 males, and about 100 copepodids from water in the burrows of the thalassinidean crustacean *Axius* (*Neaxius*) *acanthus* A. Milne Edwards (determined by Dr. Fenner A. Chace, Jr.) in sand exposed at low tide at the northeastern end of the beach at Andilana (sometimes spelled Andilah), on the northern side of Nosy Bé, Madagascar. Collected by A. G. Humes September 4, 1960. Holotype female, allotype, and 110 paratypes (55 of each sex) deposited in the United States National Museum, Washington; the same number of paratypes in the Muséum National d'Histoire Naturelle, Paris, the British Museum (Natural History), London, and the Museum of Comparative Zoology, Cambridge, Mass. The remaining paratypes are in the collection of the author.

Other specimens (from burrows presumed to be of the same host).—68 females, 64 males, and 30 copepodids along the southwestern shore of Nosy Iranja, about 55 kilometers southwest of Nosy Bé, September 7, 1960; 26 females, 6 males, and 3 copepodids in the same locality, October 7, 1960; 12 females, 9 males, and 3 copepodids at Andilana, October 8, 1960; 93 females, 96 males, and 3 copepodids at Andilana, August 8, 1960; 98 females, 47 males, and 3 copepodids at Nosy Iranja, November 4, 1963; 38 females, 60 males, and 40 copepodids at Antsakoabe, east of Andilana, November 1, 1963; 50 females, 41 males, and 22 copepodids at Navetsy, on the northernmost end of Nosy Bé, November 3, 1963; 19 females, 26 males, and 19 copepodids from Nosy N'Tangam, near Dzamandzar, Nosy Bé, December 2, 1963; and 97 females, 37 males, and 11 copepodids from the same locality, January 1, 1964.

Female.—The body length (not including the setae on the caudal rami) is 1.80 mm (1.66–1.89 mm) and the greatest width (near the posterior edge of the cephalosome) is 0.79 mm (0.70–0.86 mm), based on 10 individuals. The prosome is a little longer than the urosome, the ratio being about 1.4 : 1 (Fig. 1). The tergal plates of pedigerous segments 1–4 (Fig. 2) are well separated laterally (with acute posterolateral angles) and are ornamented, like the rest of the dorsal surface of the prosome, with small knobs and hairs. The segment of leg 5 is smaller, without produced epimera and with two groups of rather long hairs on the dorsolateral areas. An almost complete intersegmental sclerite occurs between this segment and the next. The genital segment (Fig. 3) is about 310 μ in length, without a trace of division into its two constituent somites. It is broadest in its anterior third (268 μ), has a moderate ventrolateral expansion in its middle third (211 μ), and is narrowest in its posterior third (169 μ), where the sides are nearly parallel. There is an extensive lateral invagination between the anterior and middle thirds. Details of the border of the anterior two-thirds of the genital segment are shown in Figures 4 and 5. The egg sacs are attached dorsolaterally on the anterior part of the broadened anterior third. Near the attachment of each sac there are two minute blunt spines, each about 9 μ in length (Fig. 6); posterior to the attachment area there is a single isolated small seta. Each egg sac is oval, about 507 × 253 μ (based on 3 individuals), and contains many small eggs (Fig. 1).

The spermatophores when attached to the female are carried along the posterior third of the genital segment (Fig. 1), behind the middle expansion. The three postgenital segments (Fig. 3) measure in length, respectively, 122, 96, and 72 μ, the last of these segments with a row of minute spinules on the ventral posterior margin near the insertion of the ramus. A row of smaller spinules continues laterally on the ventral posterior margin (see Fig. 7). Two diagonal rows of very fine spinules form a V on the dorsal anal area. A few minute refractile points

[1] The specific name *axiophilus* is derived from *Axius*, the generic name of the crustacean with which the copepod is associated, and φιλος, loving.

occur on the ventral surface of the first postgenital somite.

The caudal ramus (Fig. 7) measures $102 \times 53\ \mu$ (2.0 times longer than wide), based on 5 individuals, the length measured ventrally along the inner edge. The lateral seta is $88\ \mu$ in length, without hairs or spinules, but with a narrow flange along the posterior edge. The dorsal seta is $100\ \mu$ long and haired. The innermost terminal seta is $226\ \mu$ long, with erect lateral hairs; the outermost terminal seta is $83\ \mu$ long, naked, with the proximal two-thirds having an inner flange and terminating in two pointed processes, the distal third forming a hyaline flagellum (Fig. 8). Of the two long terminal setae, the outer one is $437\ \mu$ in length, the inner one $728\ \mu$, both with a basal peg and with lateral hairs. A minute hyaline setule (hair ?) occurs on the outer edge near the base of the ramus. There is a row of long setules along the distal half of the inner edge, and a small group of spinules at the inner distal corner of the ramus. The distal end of the ramus overlaps ventrally the insertions of the four terminal setae.

The rostral area (Fig. 9) bears two small hairs and a few refractile points.

The first antenna (Fig. 10) has 7 segments, their lengths (measured along their forward setiferous margins) beginning at the base: 56, 94, 55, 117, 62, 53, and $52\ \mu$, respectively. The first segment bears 4 setae, the second 15 (some of them apparently with extremely short lateral hairs in their proximal halves), the third 6, the fourth 3, the fifth 4 and 1 aesthete, the sixth 2 and 1 aesthete, and the seventh 7 and 1 aesthete. All but 6 setae are annulate, these six being disposed as follows: 1 each on segments 5 and 6, 4 on the terminal segment. On the distal anterodorsal surface of the second segment there are a few transverse refractile lines as shown in the figure.

The second antenna (Fig. 11) is 4-segmented, with the third segment produced on the inner distal corner and bearing there 2 spines, the proximal one blunt and having a spinulose flange, the distal one attenuated and bearing a row of spinules, both spines with a subterminal setule. The fourth segment measures about $36 \times 29\ \mu$ and has 3 hyaline, pectinate flanges, two on the outer side and one on its posterior surface. The remaining armature and ornamentation is shown in the figure.

The labrum in anterior (dorsal) view (Fig. 12) is slightly trilobed with a row of 5–10 setules along its free edge. In posterior (ventral) view (Fig. 13) the labrum has a complex ornamentation, as shown in the figure.

The metastomal areas have the ornamentation indicated in Figure 14, with the anterior area showing mostly hairs, the posterior one bearing spinules.

The mandible (Fig. 15) has the usual two stout elements and two spinulose setae. The paragnath (Fig. 16) is a large lobe bearing spinules and hairs. The first maxilla (Fig. 17), the second maxilla (Fig. 18), and the maxilliped (Fig. 19) present no outstanding differences from other species. Seen ventrally, the maxillipeds are connected by a line (Fig. 20) probably representing a trace of an intercoxal plate. The postoral protuberance is neither well defined nor particularly well developed.

The armature of legs 1–4 (Figs. 21, 22, 23, and 24) is as follows (the Roman numerals representing the spines, the Arabic numerals the setae):

P1	protopod	0:1	1:1	exp	I:0	1:1	I,7
				end	0:1	0:1	I,5
P2	protopod	0:1	1:0	exp	I:0	1:1	II,7
				end	0:1	0:2	I,II,3
P3	protopod	0:1	1:0	exp	I:0	1:1	II,7
				end	0:1	0:2	I,II,3
P4	protopod	0:1	1:0	exp	I:0	1:1	I,7
				end	0:1	0:2	I,II,2

The formula for the terminal segments of the exopods and endopods depends in some cases upon whether an element is interpreted as a "spine" or a "seta." Thus, when comparing the armature of the legs, reference should also be made to the figures.

Leg 1 bears on its basis an inner spine $70\ \mu$ in length, and its exopod spines have subterminal setules; both of these features

being absent on legs 2–4. On leg 3 the distalmost of the three spines on the last exopod segment is somewhat intermediate in form between a spine and a seta, and the distalmost of the three spines on the last endopod segment is nearly twice the length of the other two (48, 49, and 95 μ, respectively). The spines on all four legs have slight spinulose flanges.

Leg 5 (Figs. 25 and 26) has a rather short and broad free segment, measuring 134 × 84 μ (based on 4 specimens), or about 1.6 times longer than wide. There are rows of spinules on both outer and inner margins. The three terminal spines are 60, 57, and 68 μ in length, respectively, from outer to inner, and the terminal seta is 104 μ long. (One female from Nosy Iranja showed a normal right leg, but the left leg 5 was abnormal, lacking the innermost terminal spine and having a smooth inner margin on the free segment.) The seta arising from the body near the base of the free segment is about as long as the free segment. The area adjacent to the insertion of the free segment of leg 5 is ornamented with groups of slender setules and spines, as shown in the figures.

Leg 6 is apparently absent.

The color in living specimens in transmitted light includes red speckling along the sides of the prosome, a red eye, a gray ovary, and orange-red to gray egg sacs.

Male.—The body length (not including the setae on the caudal rami) is 1.57 mm (1.44–1.73 mm), and the greatest width is 0.67 mm (0.61–0.77 mm), based on 10 individuals. The body form (Fig. 27) in general resembles that of the female, with a similar ratio of prosome to urosome. The tergum of the fifth pedigerous segment appears to be not as clearly defined as in the female and lacks the two groups of hairs near the insertion of leg 5. The genital segment in dorsal or ventral outline is subcircular (Fig. 28), 190 μ long and 247 μ wide. The four postgenital segments are 125, 104, 72, and 62 μ in length, respectively. A few scattered refractile points and hairs may be seen on the dorsal surface of the genital and postgenital segments, as shown in the figure.

The caudal ramus is similar to that of the female but a little shorter, its average size (based on 5 individuals) being 88 × 51 μ, or about 1.7 times longer than wide.

The spermatophore attached to the body of the female (Fig. 29) is pyriform, 99 × 70 μ, not including the short neck; the spermatophore seen inside the body of the male (Fig. 30) appears to be a little smaller (86 × 62 μ).

The rostral area is like that of the female.

The first antenna is similar to that of the female, but there is an additional seta on the third and fourth segments (Fig. 31), so that the formula for the seven segments is: 4, 15, 7, 4, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete.

The second antenna resembles that of the female.

The labrum (Fig. 32) lacks the line of long setules on its anterior surface and shows a more extensive area of fine, close-set spinules medially below the free ventral edge (replacing the two rows of spinules in the female). The second metastomal area has only one row of blunt triangular spines (instead of two as in the female).

The mandible, paragnath, and first maxilla are similar to those of the female. The second maxilla (Fig. 33) shows the stout inner spine on the second segment here replaced by a strongly sclerotized, claw-like element lacking an articulation with the segment. The details of the compound element are also slightly modified (Fig. 34).

The maxilliped (Figs. 35, 36, and 37) has a single seta on the first segment. The proximal inner angle of the second segment is greatly expanded, the segment being 190 μ along its outer margin and 169 μ in greatest width. There are three rows of blunt spinules and two setae on the inner surface of this segment. It also shows three groups of cuticular furrows on its inner posterior surface, as indicated in Figure 36. The third segment is very short and unarmed. The fourth segment extends into a long claw 260 μ in length (measured along its axis and

not along the curvature) bearing near its base a slender setiform process, a slender seta, and a minute setule.

Leg 1 lacks the inner spine on the basis (Fig. 38); otherwise legs 1–4 are similar to those of the female, with the same armature.

Leg 5 (Fig. 39) has a free segment more slender than in the female, measuring about 138 × 68 μ, or about 2 times longer than wide, with its armature resembling that in the female (the three spines are 70, 68, and 74 μ in length from outer to inner, the seta 83 μ long). The processes at the outer sides of the bases of the two proximal spines are larger than in the female. The seta arising from the body near the base of the free segment is shorter than the segment; near this seta there is a row of spinules, but the group of slender setules seen in the female is absent.

Leg 6 (Fig. 40) consists of a sclerotized flap bearing laterally a seta 64 μ in length. The sclerotizations on the segment, against which these flaps fit, are particularly heavy.

The color in living specimens resembles that of the female.

Remarks on its biology.—H. axiophilus was found in water in the relatively small burrows of *Axius acanthus* but never in burrows of larger size and presumed to be inhabited by other animals. (In every collection of *H. axiophilus* the copepod next described also occurred.) It seems to show a distinct preference for the burrows of *Axius* in the Nosy Bé region. The copepod apparently lives in the burrow water and not on the body of *Axius*, since no copepods were found on the bodies of 16 *Axius* dug from their burrows. All specimens were recovered by drawing water from the burrows by means of a small bilge pump.

In artificial lighting under a binocular microscope, the copepods showed a fairly strong positive photokinesis, with the majority of them concentrating on the side of the dish nearest the light source.

Two specimens (one female and one male) were observed whose intestines contained fragments of copepods, suggesting that in part at least the food of *H. axiophilus* includes copepods.

Relationship to other species.—H. axiophilus belongs to the group of species in the genus *Hemicyclops* having four setae on the first segment of the first antenna and a short terminal segment on the second antenna. It seems to be closest to *H. visendus* Humes, Cressey, and Gooding, 1958 (found associated with *Upogebia* at Nosy Bé). It differs from that species, however, in several respects. In the female of *H. visendus* the caudal ramus is about 1.7 times longer than wide, a rather large number of the setae on the first antenna have conspicious lateral hairs, and the genital segment does not show two lateral expansions; in the male the body length is 2.06 mm, the genital segment is subrectangular in dorsal or ventral outline rather than subcircular, the second segment of the maxilliped is pyriform in outline rather than subtriangular, and the free segment of leg 5 is elongate, being 2.4 times longer than wide.

Hemicyclops amplicaudatus[1] n. sp.

Pl. VII, figs. 41–46; Pls. VIII–X; Pl. XI, figs. 71–72

Type material.—7 females and 17 males from water in burrows of *Axius* (*Neaxius*) *acanthus* A. Milne Edwards (determined by Dr. Fenner A. Chace, Jr.) in sand exposed at low tide along the southwestern shore of Nosy Iranja, about 55 kilometers southwest of Nosy Bé, Madagascar. Collected by A. G. Humes September 7, 1960. Holotype female, allotype, and 11 paratypes (2 females and 9 males) deposited in the United States National Museum, Washington; 6 paratypes (1 female and 5 males) in the Museum of Comparative Zoology, Cambridge, Mass.; and the remaining paratypes in the collection of the author.

Other specimens (from burrows pre-

[1] The specific name *amplicaudatus*, from Latin *amplus* = wide, broad, and *cauda* = tail, refers to the unusually wide genital segment in this species.

sumed to be of the same host). — 13 females and 13 males on the northeastern end of the beach at Andilana, on the northern side of Nosy Bé, September 4, 1960; 7 females from the same locality, October 8, 1960; 11 females, 3 males, and 1 copepodid again from the same locality, August 8, 1963; 9 females and 1 male from Nosy Iranja, November 4, 1963; 9 females and 1 male from Antsakoabe, east of Andilana, November 1, 1963; 6 females and 5 males from Navetsy, on the northernmost end of Nosy Bé, November 3, 1963; 30 females and 21 males from Nosy N'Tangam, near Dzamandzar, Nosy Bé, January 1, 1964; and 10 females and 2 males from the same locality, December 2, 1963.

Female.—The length of the body (not including the setae on the caudal rami) is 1.34 mm (1.24–1.42 mm), and the greatest width (in the posterior third of the cephalosome) is 0.57 mm (0.53–0.62 mm), based on 10 individuals. The prosome is distinctly longer than the urosome (Fig. 41), the ratio being about 1.5 : 1. The epimera of pedigerous segments 1–4 are laterally somewhat rounded and closely imbricate, those of the segment bearing leg 4 partly covered by the tergal area of the preceding segment. The dorsal surface of the prosome bears scattered hairs mounted on refractile points; these hairs extend around onto the ventral edges of the cephalosome (Fig. 42). The segment bearing leg 5 has dorsally two raised lobes, each bearing a somewhat ragged membranous fringe along the outer edge and resembling reduced epimera (Figs. 43 and 61). The genital segment (Figs. 43 and 44) is greatly widened, 280 μ in length (including the attached spermatophores) $\times$ 325 μ in greatest width. An intersegmental sclerite extends ventrally and laterally between the segment of leg 5 and the genital segment. The egg sacs are attached far forward and laterally on the genital segment, lying dorsally to the fifth legs. Each egg sac is moderately elongated (Fig. 41), about 430 $\times$ 154 μ, and contains many small eggs.

The spermatophores are cemented firmly to the posterolateral areas of the genital segment in all females observed (Figs. 43 and 44).

The three postgenital segments measure 75, 53, and 41 μ in length, respectively. The surfaces of these segments (and the genital segment) show a few hairs and refractile points, as indicated in the figures. The last postgenital segment has dorsally a flap-like operculum (Fig. 45) extending into the wide anal area. The sides of the aperture are finely rugose so as to produce the appearance of striations around the operculum. The last segment bears a short row of very small spinules on its ventral posterior margin near the insertion of each ramus.

The caudal ramus (Fig. 45) is inserted somewhat ventrally, and measures 71 $\times$ 20 μ, about 3.6 times longer than wide, the length being taken along the inner edge. A small hyaline hair (setule ?) is situated on the outer margin near the base. The dorsal seta has lateral hairs. The lateral seta and the outermost terminal seta have minute spiniform projections about midway along their lengths (two such projections on the former and one on the latter), beyond which the setae are annulated. The innermost distal seta is 112 μ in length, with conspicuous lateral hairs along the inner edge and less well-developed hairs along the outer edge. The inner long terminal seta is 414 μ in length, the outer 240 μ, both with short outer spinules and long inner hairs and both showing a basal peg. The distal end of the ramus overlaps ventrally the insertions of the four terminal setae.

The rostral area (Fig. 46) is slightly protuberant anteriorly but weakly developed, with a few hairs as shown in the figure.

The first antenna (Fig. 47) is 7-segmented, about 350 μ in length, the lengths of the segments from the base, respectively, 20, 49, 49, 58, 44, 50, and 38 μ (measured along their non-setiferous margins). The first segment bears 4 setae, the second 15, the third 6, the fourth 3, the fifth 4 and 1 aesthete, the sixth 2 and 1 aesthete, and the seventh 7 and 1 aesthete; the formula thus

being the same as in *H. axiophilus*. The aesthetes on segments 5 and 6 have their basal portions (about one-fifth) sclerotized like a seta. All the long setae are annulated and naked. The longest seta on the last segment is unusually long, about 290 μ.

The second antenna (Fig. 48) is 4-segmented, with the third segment considerably produced on the inner (anterior) corner and bearing four elements: two of them relatively short spines with a flange of spinules on the anterior side and a subterminal setule, the third very long and strongly recurved with annulations and a spinulose flange (Fig. 49), and the fourth a naked annulated seta. The fourth segment is subcylindrical, 40 × 20 μ, and bears 7 setae, of which the outermost has distinct lateral hairs and is relatively short; the remaining 6 setae are either naked or show very short lateral spinules as indicated in the figure.

The labrum (Fig. 50) is slightly trilobed, with teeth and setules as shown in the figure. The two metastomal areas have a complex ornamentation, as indicated in Figure 50.

The mandible (Figs. 51 and 52) is provided terminally with two stout elements of unusual shape for the genus, both of them edged with tooth-like serrations (perhaps modified spines ?) and the outer one having a dorsal protuberance that fits into a concavity on the adjacent element, and with two inner spinulose spines. The paragnath (Figs. 50 and 53) is an elongated hairy lobe. The first maxilla (Fig. 54) is similar to that of other species. The second maxilla (Fig. 55) has the same armature as in that of other species, but the ornamentation of the spines and setae is less strongly developed, and the accessory spinous processes of the terminal compound element are replaced by spinulose flanges. The maxilliped (Fig. 56) is small and rather slender. The bases of the two maxillipeds are connected ventrally by a weak line perhaps representing a trace of the intercoxal plate.

The armature of legs 1–4 (Figs. 57, 58, 59, and 60) has the same formula as in *H. axiophilus*. The element distal to the two outer spines on the third exopod segment of all four legs is here considered as a modified seta, since it shows annulations. The outer seta on the basis of legs 2 and 3 is relatively short, but in legs 1 and 4 this seta is long, reaching 200 μ in length in leg 4 (longer than the entire exopod which is about 140 μ long).

Leg 5 (Fig. 61) has two segments, the distal one elongate, 110 × 34 μ, or about 3 times longer than wide. There are rows of long spinules on both outer and inner margins. The three spines measure 49, 35, and 54 μ in length, respectively, from outer to inner. The seta is 99 μ long. The seta on the basal segment of the leg is 112 μ in length.

Leg 6 is apparently absent.

In life, in transmitted light, the body is nearly colorless, the eye red, and the spermatophores brownish.

Male.—The body length (not including the setae on the caudal rami) is 1.0 mm (0.92–1.0 mm) and the greatest width is 0.39 mm (0.35–0.41 mm), based on 10 individuals. The form of the body (Fig. 62) is much like that of the female. The ratio of the length of the prosome to that of the urosome is about 1.4 : 1. The segment bearing leg 5 shows dorsally the two raised lobes only weakly developed, and lacks the membrane seen in the female. The genital segment (Fig. 63) is widened, 195 μ in length × 234 μ in greatest width, with its lateral margins more evenly rounded than in the female. The four postgenital segments are 65, 55, 43, and 36 μ in length, respectively. There are scattered hairs and refractile points over the surface of the urosome as shown in the figure.

The caudal ramus resembles that of the female.

The spermatophore while inside the body of the male has the form shown in Figure 63, with its neck arising subterminally on the inner anterior margin. The greatest length of the spermatophore is 130 μ, the width anterior to the neck 78 μ, and the width in the posterior third 49 μ.

The rostral area is like that of the female.

The first antenna is similar to that of the female, but the third and fourth segments have an additional seta (7 and 4, respectively, as in the male of *H. axiophilus*), indicated in Figure 64.

The second antenna resembles that of the female.

The labrum, metastomal areas, mandible, paragnath, and first maxilla are essentially like those of the female.

The second maxilla (Figs. 65 and 66) has the large dorsal spine transformed into a very large, blunt, strongly sclerotized, claw-like process. The compound element is also modified.

The maxilliped (Fig. 67) has a single seta on the first segment. The second segment has its proximal inner angle greatly expanded, with the inner margin of the segment being distinctly curved (not almost straight as in *H. axiophilus*). The length of this segment is 150 μ along the outer edge and its greatest width is 117 μ. Along its inner surface there are two rows of stout spines and a row of slender spinules, plus the usual two small setae. The third segment is very short and unarmed. The fourth segment forms part of the long claw which is 179 μ in length (measured along its axis and not along the curvature). The claw has an interrupted membranous fringe along part of its concave edge, and near its base bears two small setae (the one on the anterior surface of the claw annulate) and a spinous process, as shown in the figure. A distinct transverse line may be seen ventrally between the bases of the maxillipeds (Fig. 68), probably representing the edge of the intercoxal plate.

Leg 1 lacks the inner spine on the basis (Fig. 69); otherwise legs 1–4 are similar to those of the female, with the same spine and setal formula but with somewhat larger endopod spines.

Leg 5 (Fig. 70) has a single free segment which is shorter than in the female, measuring 99 × 43 μ, or about 2.3 times longer than wide. Its armature resembles that of the female (the three spines being 53, 47, and 53 μ in length, respectively, from outer to inner, and the seta 66 μ). The seta on the basal area is shorter than in the female (about 60 μ in length).

Leg 6 (Figs. 71 and 72) consists of a ventrolateral posterior flap bearing a spine 47 μ in length with fine lateral spinules.

The color in life resembles that of the female.

Remarks on its biology.—Each time that *H. amplicaudatus* was collected it was found in company with *H. axiophilus*, though in smaller numbers. As in the case of *H. axiophilus*, this species seems to show a preference for *Axius* burrows, apparently living in the water rather than on the bodies of the crustaceans, since no copepods were recovered after washing the bodies of *Axius*.

Relationship to other species.—*H. amplicaudatus* differs in its unusually broad genital segment from all known species of *Hemicyclops* that have four setae on the first segment of the first antenna. Only one species, *H. aberdonensis* (T. and A. Scott, 1892), shows a genital segment approaching that of *H. amplicaudatus* in width, but here the shape is very different (see the Scotts' pl. VI, figs. 1 and 12). Other distinctive features are the form of the spermatophores, the unusually long, recurved, fringed spine on the third segment of the second antenna, and the unusual shape of the two stout elements on the end of the mandible.

Hemicyclops carinifer[1] n. sp.

Pl. XI, figs. 73–81; Pls. XII–XV; Pl. XVI, figs. 109–115

Type material.—16 females and 4 males from water in burrows 3–4 cm in diameter and more than 90 cm deep, of unknown origin, in intertidal sand at Bamoko, 3 kilometers north of Dzamandzar, Nosy Bé, Madagascar. Collected by A. G. Humes October 22, 1960. Holotype female, allotype, and 11 paratypes (10 females and 1

[1] The specific name *carinifer*, from Latin *carina* = a keel, and *ferre* = to bear, alludes to the keel-like ridge on the ventral area between the maxillipeds and the first pair of legs.

male) deposited in the United States National Museum, Washington; 6 paratypes (5 females and 1 male) in the Museum of Comparative Zoology, Cambridge, Mass.; and one dissected paratype male in the author's collection.

Other specimens (from similar burrows).—19 females in sand near the village of Antafiabe, on the western shore of Nosy Faly, an island to the east of Nosy Bé, October 21, 1960; 1 female in sand on the southeastern shore of Nosy Sakatia, opposite the village of Antanambe, about 3 kilometers west of Nosy Bé, October 23, 1960; 16 females, 11 males, and 1 copepodid in muddy sand at the Centre d'Océanographie et des Pèches, Pointe à la Fièvre, Nosy Bé, August 28, 1960; 2 females from the same locality, August 22, 1960; 1 female in muddy sand near mangroves at Ambanoro, across the bay from the Centre d'Océanographie et des Pèches, Nosy Bé, August 23, 1960; 36 females, 9 males, and 1 copepodid from sand west of Pte. Ambarionaomby, Nosy Komba, March 14, 1964; 10 females from the same locality, March 28, 1964; 21 females and 5 males in sand at Bamoko, Nosy Bé, February 29, 1964; 2 females and 1 male from sand at Antviabe, on the southern shore of Nosy Komba, March 16, 1964; 6 females from sand at Nosy Kisimany, 25 kilometers southwest of Nosy Bé, April 12, 1964; 2 females from sand at Madirokely, Nosy Bé, April 28, 1964; 12 females and 2 males from sand at Befotaka, Nosy Bé, April 29, 1964; 22 females and 12 males from sand at Nosy Roty, near Nosy Sakatia, May 12, 1964; 6 females and 2 males from muddy sand at Ampassipohe, Nosy Bé, May 11, 1964; and 1 female from sand at Boloboxo, Nosy Faly, May 13, 1964.

Female.—The length of the body (excluding the setae on the caudal rami) is 1.42 mm (1.32–1.55 mm), and the greatest width (in the posterior half of the cephalosome) is 0.50 mm (0.45–0.52 mm), based on 10 individuals. The body (Fig. 73) has a rather slender form, the prosome being only slightly longer than the urosome, with the ratio 1.18 : 1. The dorsal body surface has relatively few small hairs. The epimera are prominent but have subacute or rounded posterolateral angles in dorsal or ventral view. The genital segment (Fig. 74) is wider than long, 132 × 161 μ, broadest in its anterior third, and with the median posterior dorsal surface raised and abruptly truncated (Fig. 75), forming a transverse crescentic sclerotized line in dorsal view. The egg sacs are attached dorsolaterally near the widest part of the segment. Near the attachment of each egg sac there are three slender naked setae (Fig. 76), 62, 57, and 23 μ in length, respectively, borne within the genital area surrounding the oviducal opening. Each sac is slender and elongated, 560 × 123 μ, held parallel to the abdomen in preserved specimens, and containing 4 rows of approximately 12 eggs each (Fig. 77).

No spermatophore was found attached to the female.

The four postgenital segments measure 91, 78, 55, and 117 μ in length, respectively. The anal segment (Figs. 78 and 79) has a posterior fringe of small spinules extending from each side dorsally and ventrally near the insertions of the rami; this segment shows dorsally a large, oval, weakly sclerotized anal region and ventrally a pair of transverse rows of slender spinules near the anterior edge.

The caudal ramus (Fig. 80) measures 220 × 27 μ (the width taken at its midregion, the length along its inner edge), about 8.0 times longer than wide. A small hyaline hair (setule ?) is situated on the outer margin in the proximal third. The lateral seta is naked, 49 μ in length. The dorsal seta, borne on a minute basal segment, is naked, 122 μ long. The outermost terminal seta is naked, 59 μ long. Of the 2 long terminal setae, the outer one is 426 μ and the inner one 280 μ in length, both with a basal peg and with lateral hairs. The innermost terminal seta is 114 μ in length and haired along its inner edge. The distal end of the ramus slightly overlaps ventrally the insertions of the 4 terminal setae.

The rostral area (Fig. 81) is small and inconspicuous, set off from the anterior surface of the head by a furrow, and protruding ventrally.

The first antenna (Fig. 82) is about 582 μ in length, with 7 segments, in length from the base, 55, 91, 33, 130, 83, 83, and 106 μ (measured along their forward setiferous margins). The first segment bears 5 setae, the second 15, the third 6, the fourth 3, the fifth 4, the sixth 2 and 1 aesthete, and the seventh 7 and 1 aesthete. Certain of the setae have lateral hairs, as indicated in the figure. The terminal aesthete seems to insert independently of any seta.

The second antenna (Fig. 83) is 4-segmented, with the third segment not produced on the inner distal corner and bearing there 4 setae as indicated, the largest similar in structure to the 4 terminal curved setae; the last segment is slender and elongated, 105 × 22 μ, about 4.8 times longer than wide, with the usual 7 elements. The long spinules along the edges of the third and fourth segments are rather flattened and have brush-like tips (as in Fig. 84).

The labrum (Fig. 85) has the usual transversely oval shape, its free margin having a row of large teeth, its sublateral areas a few spinules, and its lateral areas groups of hairs.

The metastomal areas (Fig. 86) have an ornamentation as shown in the figure.

The mandible (Fig. 87) has a terminal armature consisting of a stout spine with teeth on each side, two more slender lamelliform spines bearing lateral spinules, and a very small spinule. The paragnath (Fig. 88; see also Fig. 86) is a lobe bearing a distal row of teeth (broad spinules ?), a small semicircular subapical lobe, and two groups of hairs on its posterior surface which merge into a proximal patch; the more ventral row of these hairs continues distally into a line of minute denticles. The first maxilla (Fig. 89) and the second maxilla (Fig. 90) have the number and arrangement of the spines and setae similar to other species, but with minor differences in their lateral spinules as indicated in the figures. The maxilliped (Fig. 91) has a large inner process on the fourth segment, this process being distinctly bent, approaching an S in contour; there are 2 slender setae arising from the terminal segment; the tips of the S-shaped process and of the terminal element are rather blunt, while the proximal seta on the first segment and the 2 setae on the second segment have minutely bifid tips (see Fig. 92). The bases of the maxillipeds are connected ventrally by a cuticular line (Fig. 93) probably representing a trace of the intercoxal plate.

The area between the bases of the maxillipeds and the first pair of legs, forming the postoral protuberance, lacks ornamentation but shows prominent lateral sclerites (Fig. 93), and is produced medially to form a longitudinal keel (Fig. 94).

The armature of legs 1–4 (Figs. 95, 96, 97, and 98) is as follows:

P1	protopod	0:1	1:1	exp	I:0	I:1	III,5
				end	0:1	0:1	I,5
P2	protopod	0:1	1:0	exp	I:0	I:1	III,6
				end	0:1	0:2	I,II,3
P3	protopod	0:1	1:0	exp	I:0	I:1	I,II,5
				end	0:1	0:2	I,III,2
P4	protopod	0:0	1:0	exp	I:0	I:1	I,II,5
				end	0:1	0:1	I,III

Leg 1 bears on the basis a straight inner spine 50 μ in length; the outer distal corner of the second endopod segment of this leg forms a spiniform process. Leg 4 shows the rami relatively more elongated than in the preceding legs; the last endopod segment has four spines, 31, 52, 87, and 26 μ in length from outer to inner, respectively. The coxa of leg 4 lacks an inner seta. All four legs show minute flagella near the tips of the outer exopod spines. Legs 1–3 show 2–3 unusually strong lateral spinules on the outer side of the bases of certain of the distal setae on the last endopod segment, as shown in the figures.

Leg 5 (Fig. 99) has a ventral row of spinules near the seta on the basal segment. The distal segment is elongated, 114 μ

along its inner edge; it is wider in its basal half (45 μ) than in its distal half (36 μ), and deeply indented at the insertion of the lateral seta. There is an outer marginal row of spinules on the basal half, and a similar inner row of spinules along part of the margin of the distal half. The outer margin forms a blunt projection near the insertion of the marginal spine and also near the distal outer spine; there is a row of slender spinules ventrally on these projections. There is also a row of minute spinules ventrally near the insertion of the inner distal spine. The 3 spines and the seta measure 42, 42, 77, and 49 μ in length from outer to inner, respectively.

Leg 6 is apparently absent, but may be represented by the 3 setae near the egg sac attachments.

The color in living specimens, in transmitted light, is translucid, slightly amber or reddish brown, with reddish orange globules in the prosome, the ovary dark gray, the eye red, and the egg sacs reddish gray to orange.

Male.—The body length (not including the setae on the caudal rami) is 1.61 mm (1.57–1.66 mm) and the greatest width is 0.55 mm (0.53–0.58 mm), based on 4 individuals. The ratio of the prosome to urosome is 1.35 : 1, with the prosome only slightly longer (Fig. 100) than in the female. The genital segment (Fig. 101) is nearly quadrate in dorsal or ventral view, measuring 156 × 151 μ. The 4 postgenital segments have proportions similar to those of the female. The ornamentation of the anal segment is also like that in the female.

The caudal ramus is as in the female.

Spermatophores were seen only inside the genital segment of the male (Fig. 101).

The rostral area resembles that of the female.

The first antenna is similar to that of the female, but the third segment has 7 setae and the fourth 4 setae (see Fig. 102).

The second antenna is like that of the female.

The labrum (Fig. 103) has a row of slender spines along its free edge and a row of additional, broad, scale-like denticles curving dorsally along the posteroventral face on either side. The metastomal areas are much like those of the female, but the most posterior rows of spines are smaller (Fig. 104).

The mandible, paragnath, first maxilla, and second maxilla are similar to those of the female.

The maxilliped (Figs. 105 and 106) has 2 unequal setae on the first segment, the proximal seta with prominent lateral spinules, the distal one naked. The second segment is slender, 239 × 101 μ, with 2 rows of broad spinules and 2 annulated setae on its inner surface; one of these rows is interrupted by the bases of the setae, proximal to which the row becomes a series of blunt serrations and then a group of broad spinules. The third segment is short and unarmed. The fourth segment forms part of the claw, which is 260 μ in length (measured along its axis and not along the curvature), slightly sinuous in outline, and with a distinct flexure near its tip, where there is a small outer lamella and 2 rows of denticle-like ridges which decrease in size proximally. Near the base of the claw there may be seen a setiform process and 3 slender setae (the one nearest to the process recurved and unilaterally haired) (see Fig. 107).

The postoral area between the bases of the maxillipeds and the first pair of legs (Fig. 108) is raised to form a ventral longitudinal keel (Fig. 109). This keel bears a row of serrations along its edge, a short transverse crescentic row of irregular serrations anteriorly, and laterally a few minute refractile points. Between the bases of the second maxillae there is a minute bifurcated sclerotization.

Legs 1–4 have the same number and arrangement of spines and setae as in the female. The inner spine on the basis of leg 1 (Fig. 110) is larger than in the female and slightly recurved, about 77 μ in length, with a transverse weakening in the sclerotization in its basal third, a row of minute refractile points, and a cluster of rather

blunt minute spinules near its tip (Fig. 111). The second endopod segment of leg 1 does not show a distal outer spiniform process as in the female. The middle spine on the outer side of the third exopod segment of leg 1 is relatively smaller than in the female. Leg 2 shows the 3 spines on the third endopod segment of different proportions than those of the female, their lengths from outer to inner being 38, 28, and 77 μ, the middle spine being distinctly shorter and more slender (Fig. 112). There is on this endopod only a single terminal spiniform process. (One male showed the distal margin of the third endopod segments of leg 3 with a single spiniform process between the 2 middle spines on one leg, and with a bifurcated process at this point on the opposite leg, as indicated in Fig. 113).

Leg 5 (Fig. 114) is similar to that of the female, but the row of spinules on the distal inner margin of the distal segment is shorter, and the processes near the bases of the 2 outermost spines are more acute than rounded.

Leg 6 (Fig. 115) consists of a small ventrolateral flap on whose extreme lateral portion a slender seta 34 μ in length is borne on a slight prominence.

The color in living specimens resembles that of the female.

Remarks on its biology.—H. carinifer frequently occurred in the same burrows with the following species (in 10 of 16 collections).

Relationship to other species. — This copepod falls in the group of *Hemicyclops* species having five setae on the first segment of the first antenna, an elongated terminal segment on the second antenna, and elongated caudal rami. Four species attributable to this group (*H. elongatus* Wilson, 1937, *H. adhaerens* (Williams, 1907), *H. subadhaerens* Gooding, 1960, and *H. arenicolae* Gooding, 1960) have in the female a caudal ramus which is much shorter than in *H. carinifer* (only a little more than 4 times longer than wide, or less). These species also appear (as nearly as can be ascertained from the published descriptions) to lack two features of *H. carinifer*, namely, the projections near the insertions of the two outer spines on the distal segment of leg 5, and the keel on the ventral surface between the maxillipeds and the first legs.

Hemicyclops diremptus[1] n. sp.

Pl. XVI, figs. 116–117; Pls. XVII–XX; Pl. XXI, figs. 147–152

Type material.—6 females and 5 males from burrows of unknown origin 3–4 cm in diameter and more than 90 cm deep in intertidal sand near the village of Antafiabe, on the western shore of Nosy Faly, an island to the east of Nosy Bé, Madagascar. Collected by A. G. Humes October 21, 1960. Holotype female, allotype, and 3 paratypes (2 females and 1 male) deposited in the United States National Museum, Washington; 2 paratypes (1 female and 1 male) in the Museum of Comparative Zoology, Cambridge, Mass.; and the remaining paratypes in the author's collection.

Other specimens (from similar burrows). —1 male from sandy mud in front of the Centre d'Océanographie et des Pêches, Nosy Bé, August 22, 1960; 8 females in sand west of Pte. Ambarionaomby, Nosy Komba, March 14, 1964; 2 females from the same locality, March 28, 1964; 1 male from sand north of Antafiabe, Nosy Faly, March 15, 1964; 5 females and 13 males from sand at Nosy Kisimany, April 12, 1964; 1 female and 2 males from sand at Madirokely, Nosy Bé, April 28, 1964; 176 females and 118 males from sand at Befotaka, Nosy Bé, April 29, 1964; 77 females and 21 males from sand at Nosy Roty, near Nosy Sakatia, May 12, 1964; 15 females and 22 males from muddy sand at Ampassipohe, Nosy Bé, May 11, 1964; and 1 female and 2 males from sand at Boloboxo, Nosy Faly, May 13, 1964.

Female.—The length of the body (not including the setae on the caudal rami) is

[1] The specific name *diremptus*, from Latin *dirempere* = to separate, divide, alludes to the divided condition of the genital segment in the female.

1.90 mm (1.82–1.97 mm), and the greatest width (in the posterior part of the cephalosome) is 0.81 mm (0.76–0.87 mm), based on 6 individuals. The prosome is moderately broad and a little longer than the urosome, the ratio being about 1.37 : 1 (Fig. 116). In dorsal or ventral view the epimera are conspicuous and angulate. The segment bearing leg 5 is narrow in front and broadened posteriorly at the level of the legs, where it shows a dorsal transverse sclerotized ridge (probably a remnant of the epimeron of this segment). An intersegmental sclerite occurs between the first two urosomal segments. The genital segment (Figs. 117, 118, and 119) is widened and divided transversely into an anterior portion bearing the attachments of the egg sacs and a slightly narrower posterior portion. The length of the genital segment is 195 μ, the anterior part being 117 $\times$ 273 μ and the posterior part 78 $\times$ 229 μ.

The egg sacs are attached dorsolaterally on the anterior half of the genital segment between small dorsolateral and more extensive ventrolateral flanges (see Fig. 119). Each egg sac is about 560 $\times$ 200 μ, and contains numerous small eggs (Figs. 116 and 117).

The three postgenital segments measure respectively 114 $\times$ 178 μ, 62 $\times$ 133 μ, and 62 $\times$ 114 μ, the first segment being longer, wider, and more globose than the other two, which are somewhat more closely associated. The last segment has near the insertion of each caudal ramus a ventral transverse row of about four small spinules followed by a row of much smaller spinules (see Figs. 119, 120, and 121). The thinly sclerotized anal area occupies virtually the whole dorsal side of the anal segment. There is no anal plate, but the posterior edge of the preceding postgenital segment is modified (see Fig. 121).

The dorsal surface of the prosome and the dorsal and ventral surfaces of the urosome are covered with minute hairs, each arising from a refractile point.

The caudal ramus (Fig. 121) is elongated, 117 $\times$ 24 μ (the length measured along the inner edge and the width at the middle of the ramus), nearly 5 times longer than wide. A small hyaline hair occurs on the basal outer margin and a few minute hairs are to be found on the ventral surface. The lateral seta is 47 μ in length and the outermost terminal seta is 65 μ, including the basal shaft and the distal flagelliform part. The dorsal seta is 91 μ long and bears only a few lateral hairs. The innermost terminal seta is 112 μ in length with an inner row of hairs. The inner long terminal seta is 728 μ and the outer one 437 μ in length, both with lateral spinules, these being at first widely spaced and long, then in the distal two-thirds of the setae short and closely spaced.

The rostral area (Fig. 122) is very weakly developed.

The first antenna (Fig. 123) is about 400 μ long, 7-segmented, the segments, beginning at the base, 20, 55, 52, 88, 51, 55, and 47 μ in length (measured along their non-setiferous margins). The formula for the armature is 4, 15, 6, 3, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete. Most of the setae are annulated with minute lateral hairs, but there are a few setae which are entire with longer lateral hairs (1 on the second segment, 2 on the fifth, 1 on the sixth, and 4 on the seventh).

The second antenna (Fig. 124) is 4-segmented, with the third segment produced on the inner distal corner where it bears four elements: proximally a small posterior seta, more distally a large and slightly sinuous spine, and distally two more slender and somewhat recurved spines with subterminal setules. The fourth segment is quadrate in flat view, 29 $\times$ 29 μ, and bears seven setae, the four long curved setae with their tips not as attenuated as the others, and the outermost of these seven setae lying across the bases of the others and having long lateral spinules.

The labrum (Fig. 125) is tilted forward, so that the ventral view shown in the figure is equivalent to posterior in other species.

The labrum is somewhat trilobed and has setules and teeth as shown in the figure; there is a curved row of long hyaline setules along the anteroventral margin. The metastomal areas have a complex ornamentation, as indicated in Figure 125.

The mandible (Fig. 126) has the usual two stout elements and two well-developed setae with lateral hairs. The paragnath (Figs. 125 and 127) is a stout hairy lobe. The first maxilla (Fig. 128) is similar in structure to that of other species; it has prominent lateral spinules on certain of the setae. The second maxilla (Fig. 129) is armed as in other species, the innermost spine on the second segment having long outer spinules. The maxilliped (Fig. 130) shows the two setae on the second segment with prominent lateral spinules, and the margin distal to these two setae bears a row of hairs. The last maxilliped segment (Fig. 131) bears two large setae (spines?) (one of them with about five very long slender spinules on its inner margin), four more slender setae, and a row of 4–5 slender hyaline setules on the outer side near the bases of the spines. The bases of the maxillipeds are connected by a ventral transverse line as indicated in Figure 125.

The postoral protuberance is poorly differentiated.

The armature of legs 1–4 (Figs. 132, 133, 134, and 135) is similar to that of *H. axiophilus* and *H. amplicaudatus*, although certain elements are difficult to classify as a "spine" or a "seta." In leg 1 the inner spine on the basis is 65 μ in length, its inner margin serrated and its outer margin with a row of short hairs; the margin of the basis medial to this spine is prominently rounded and smooth. In legs 2–4 this inner area of the basis has a broadly rounded margin and bears a row of short marginal setules and another row of hyaline spinules on its anterior surface. The ventral margin of the intercoxal plate of leg 1 bears on each side a row of hairs; in legs 2–4 this margin has on each side a patch of long spinules. The outer margin of the coxa of leg 4 lacks the long hairs seen in the preceding three legs.

Leg 5 (Fig. 136) has a rather broad and short free segment (its greatest diagonal length from the outer proximal corner to the inner distal angle 143 μ, its length along the inner side 125 μ, its greatest width 105 μ). There are rows of spinules on the distal half of both the outer and inner margins. The three spines are 48, 63, and 50 μ in length, respectively, from outer to inner; the seta is very short, only 34 μ in length. A row of spinules occurs laterally on the basal area of the leg just anterior to the insertion of the free segment. The seta on the basal area is 68 μ long. Traces of a basal segment may be seen in the pattern of sclerotization on the segment of leg 5; the fifth legs are joined ventrally by a strong ridge near the posterior edge of this segment.

Leg 6 is apparently absent.

The color in living specimens, in transmitted light, is translucid, the eye red.

Male.—The length of the body (not including the setae on the caudal rami) is 1.14 mm (1.04–1.28 mm) and the width in the posterior part of the cephalosome is 0.48 mm (0.44–0.52 mm), based on 4 individuals. The ratio of the length of the prosome to that of the urosome is about 1.36 : 1 (Fig. 137). The epimera are prominent as in the female. The genital segment (Fig. 138) is undivided and subcircular in dorsal or ventral view, 143 μ long $\times$ 174 μ wide. The spermatophore (seen only within the body of the male) is elongated (Fig. 139), 99 $\times$ 36 μ including the neck of 13 μ.

The four postgenital segments are respectively 68, 60, 40, and 40 μ in length.

There are hairs and refractile points on both the urosome and prosome as in the female, but the general sclerotization seems to be stronger.

The caudal ramus (Fig. 140) is shorter than in the female, 55 μ (the length along the inner edge) $\times$ 28 μ (the greatest width), or two times longer than wide. The setae are arranged as in the female.

The rostral area (Fig. 141) is a little better defined than in the female.

The first antenna is similar to that of the female, but the third segment has 7 setae and the fourth 4 setae (Fig. 142). The second antenna is like that of the female.

The labrum and the metastomal areas (Fig. 143) are generally like those of the female, but the long hyaline setules on the anteroventral margin of the labrum are absent, and the second metastomal area shows only a single row of broad tooth-like spines.

The mandible, paragnath, and first maxilla are like those of the female. The second maxilla (Fig. 144) is similar to that of the female, but the spinules on the innermost spine of the second segment are much less developed.

The maxilliped (Figs. 145 and 146) has a single long seta on the first segment. The second segment has its proximal inner angle greatly expanded, making the segment almost pyriform in outline. The length of this segment along the outer margin is 114 μ, its greatest length along the inner spinose margin is 143 μ, and the greatest width is 112 μ. There are three rows of stout, rather blunt spines along the inner margin, in addition to the usual two setae. The third segment is very short and unarmed. The fourth segment forms part of a long claw 148 μ in length (measured along its axis and not along the curvature), bearing near its base a small seta on the posterior side, and a spinous process and a minute setule on the inner curvature. The transverse line on the ventral surface between the bases of the maxillipeds is weakly developed.

Leg 1 lacks the inner spine on the basis (Fig. 147). Otherwise the spine and setal formula of legs 1–4 is like that of the female. There is a slight sexual dimorphism in the last endopod segment of legs 2–4 (Figs. 148, 149, and 150), where the terminal spine-like processes are reduced and the sclerotization at the base of the two distal spines is stronger.

Leg 5 (Fig. 151) has a free segment which is not as broad as in the female, measuring 85 μ long (along the inner side) × 51 μ in greatest width. Its armature is like that of the female.

Leg 6 (Fig. 152) consists of a ventral flap on the posterior part of the genital segment. It bears a stout spine 30 μ long with minute lateral spinules.

The color is like that of the female.

Remarks on its biology.—H. diremptus was often found in burrows along with *H. carinifer* (in 10 of 11 collections).

Relationship to other species.—H. diremptus belongs to the group of species with four setae on the basal segment of the first antenna, along with *H. axiophilus* and *H. amplicaudatus.* It differs from all other species in this group in having a distinctly divided genital segment in the female. In the original description of *H. bacescui* (Şerban, 1956) the genital segment is described as double, and Stock (1959), who has restudied the species, mentions a trace of a suture on its dorsal surface. The division is much weaker, however, than in *H. diremptus. H. bacescui* further differs from the new species in the form of the fifth legs and the caudal rami. *H. indicus* Sewell, 1949, shows lateral indentations on the female genital segment (see Sewell's fig. 16A), but the segment is single. Although this species shows certain similarities to *H. diremptus* (for example, in the form of the fifth legs and in the armature of the second maxilla), it differs in the form of the caudal ramus, in the relative length of the second and third segments of the first antenna, and in the size of the body. The female of *H. leggii* (Thompson and Scott, 1903) is unknown, but the male differs from that of the new species in its body length, in the relative lengths of the first antennal segments, in the form of the innermost terminal spine on the second segment of the second maxilla, in the shape of the second segment of the maxilliped, and in the size of the caudal ramus. The fifth leg of *H. leggii* seems to resemble closely that of the new species.

Hemicyclops kombensis[1] n. sp.

Pl. XXI, figs. 153–154; Pls. XXII–XXVI

Type material.—3 females and 2 males from water in burrows of unknown origin 3–4 cm in diameter and more than 90 cm deep in intertidal sand west of Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, Madagascar. Collected by A. G. Humes March 14, 1964. Holotype female, allotype, and one paratype female deposited in the United States National Museum, Washington; the remaining female and male dissected and in the collection of the author.

Other specimens (from similar burrows).—1 male from sand in front of the village of Antviabe, on the southern shore of Nosy Komba, March 16, 1964; 1 female and 1 male from sand at Madirokely, Nosy Bé, April 28, 1964; and 1 female from sand at Nosy Roty, near Nosy Sakatia, May 12, 1964.

Female.—The length of the body (not including the setae on the caudal rami) is 2.27 mm (2.26–2.29 mm), and the greatest width is 0.83 mm (0.80–0.89 mm), based on 3 individuals. The prosome is moderately broad and only slightly longer than the urosome, the ratio being about 1.08 : 1 (Fig. 153). In dorsal or ventral view the epimera of the segments of legs 1–4 are conspicuous and angulate. The segment of the fifth legs shows a dorsal transverse sclerotized band, bearing a row of long slender spinules on each side (Fig. 154). An intersegmental sclerite, best seen from the ventral side, occurs between the first two segments of the urosome. The genital segment (Figs. 154 and 155) is elongated, with the sides nearly parallel except for slight swellings near the attachments of the egg sacs, and shows dorsally in the middle of the segment a transverse internal sclerotization. The segment measures 475 μ in length; its width in the anterior one-fourth is 305 μ and in the posterior half 271 μ.

The egg sacs are attached ventrolaterally far forward on the genital segment, between small dorsal and ventral flanges (Fig. 155). Near the point of attachment there are two minute, rather obscure spiniform processes, each about 10 μ in length. Each egg sac is elongated oval, 633 × 249 μ, and contains numerous rather small eggs (Fig. 156).

The three postgenital segments measure, respectively, 203 × 220, 140 × 184, and 92 × 158 μ. The last segment is thus shorter and narrower than the preceding ones; there is no apparent anal operculum. Above and below the insertion of each caudal ramus there are slight flanges, the dorsal one smooth, the ventral one with an outer row of minute spinules and an inner row of larger spinules (Fig. 157).

The dorsal surface of the prosome and the dorsal and ventral surfaces of the urosome bear minute hairs and refractile points.

The caudal ramus (Fig. 157) is moderately elongated, 170 μ in length, 70 μ wide near the base, 62 μ at the middle, and 54 μ near the distal end; taking the width at the middle, the ramus is 2.74 times longer than wide. A small hyaline hair arises from the outer basal margin. The lateral seta is 68 μ in length and shows only a slight differentiation into a basal shaft and a distal flagellum. The outermost terminal seta is 117 μ long, including the basal shaft of 68 μ and the distal flagelliform part of 49 μ. The dorsal seta is 149 μ long and bears a few lateral hairs. The innermost terminal seta is 260 μ in length and bears lateral spinules, those along the inner side being longer and better developed. The inner long terminal seta is 948 μ and the outer one 588 μ in length, the middle region of both bearing short outer spinules and longer inner hairs (see Fig. 153). The four terminal setae are inserted somewhat dorsally and the resulting ventral flange at the end of the ramus bears a row of minute spinules and a group of longer spinules on the inner angle. Along the distal third of the inner margin of the ramus there is a row of long slender spinules.

[1] The specific name *kombensis*, a combination made from Nosy Komba and Latin *-ensis* = living in, refers to the island where this species was first found.

The rostral area (Fig. 158) is moderately well defined.

The first antenna (Fig. 159) is about 510 μ long, 7-segmented, the segments, beginning at the base, 15, 74, 65, 110, 65, 73, and 56 μ in length (measured along their non-setiferous margins). The formula for the armature is 4, 15, 6, 3, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete. Most of the setae are annulated and a few of those on the second segment show minute lateral hairs. There are, however, certain entire setae with long lateral hairs (one on the second segment, one on the fourth, 2 on the fifth, one on the sixth, and 4 on the seventh). The armature is thus very similar to that in *H. diremptus*. On the distal anteroventral surface of the second segment there are a few transverse narrow refractile bars.

The second antenna (Fig. 160) is 4-segmented, with the third segment produced on the inner distal corner where it bears four elements: proximally a slender posterior seta, more distally a larger recurved annulated seta, and distally two slender spines bearing unilateral spinules and subterminal setules. The fourth segment is nearly quadrate in flat view, 35 μ in length $\times$ 30 μ, and bears seven setae, the four long recurved annulated setae with their tips less attenuated than the others, and the seta lying posteriorly across the bases of the long setae having conspicuous lateral spinules (Fig. 161).

The labrum (Fig. 162) is tilted forward as in *H. diremptus*, and in a ventral and somewhat posterior view has a rather trilobed appearance, with setules and teeth as shown in the figure. The metastomal areas have a complex ornamentation, as indicated in Figure 163.

The mandible (Fig. 164) has two stout elements and two well-developed setae with lateral hairs. The paragnath (Fig. 165) is a moderately elongated lobe bearing hairs and a row of delicate hyaline spinules as indicated. The first maxilla (Fig. 166) is similar in structure to that of *H. diremptus*; the lateral setules on the outermost seta, however, are longer than in that species. The second maxilla (Fig. 167) is in major respects similar to that of *H. diremptus*. The maxilliped (Fig. 168) has the same general form as in *H. diremptus*, but the two setae on the first segment are more slender, and the two setae on the second segment are relatively shorter; the last segment bears two large recurved setae (spines ?), one of them with conspicuous lateral spinules (four on one side and three on the other), and four slender setae. Between the bases of the maxillipeds there is a ventral transverse line as shown in Figure 169.

The area between the maxillipeds and the first pair of legs shows little differentiation.

The armature of legs 1–4 (Figs. 170–173) is similar to that of *H. axiophilus*, *H. amplicaudatus*, and *H. diremptus*, but again certain elements are difficult to classify as a "spine" or a "seta." In leg 1 the inner spine on the basis is 97 μ in length, with both margins bearing a narrow, finely serrated fringe. The margin of the basis medial to this spine is rounded and smooth except for a small tooth-like process near the base of the spine. In legs 2–4 this inner area of the basis bears a row of slender marginal spinules and another row of larger hyaline spinules on its anterior surface. The ventral margin of the intercoxal plate of leg 1 bears on each side a row of long hairs, but in legs 2–4 these hairs are replaced by rather stout spinules. The outer margin of the coxa of leg 4 lacks the long spinules seen on legs 1–3, but a row of slender spinules occurs on the outer posterior margin. On the last segment of the endopod of leg 4 the two inner elements are setiform, with long lateral hairs basally and short lateral spinules in the distal two-thirds.

Leg 5 (Fig. 174) has a free segment which is shaped rather like a petal, narrow at the base but broadened distally; its greatest length is 180 μ, its greatest width 98 μ, and its width basally 32 μ. There are rows of spinules on both outer and inner margins, those on the outer margin being longer than the others. The three spines are 65, 52, and 71 μ in length, respectively, from outer

to inner; the seta is 89 μ long. Rows of small spinules occur ventrally near the insertions of the three spines. The two outer spines are bilaterally fringed, but the inner spine is fringed outwardly and bears small spinules inwardly. The basal area of leg 5 shows a pattern of sclerotization which suggests a discrete segment; the seta is 110 μ long and lightly plumose distally. There is a row of small spinules adjacent to the seta.

Leg 6 is apparently absent.

The color in living specimens in transmitted light is somewhat opaque to light amber, with reddish globules in the prosome, the eye red, the egg sacs reddish brown.

Male.—The length of the body (without the setae on the caudal rami) is 2.09 mm (1.99–2.19 mm) and the greatest width is 0.77 mm, based on 2 individuals. The ratio of the length of the prosome to that of the urosome (Fig. 175) is about the same as that in the female. The epimera of the segment bearing leg 4 are less angular than in the female. The genital segment (Fig. 176) measures 240 × 287 μ, being wider than long, constricted anteriorly, with the posterolateral areas pointed. Spermatophores were not seen in any of the males collected.

The four postgenital segments measure, respectively, 221 × 205, 170 × 167, 124 × 148, and 82 × 140 μ.

As in the female, the prosome and the urosome bear hairs and refractile points. The general sclerotization of the body is stronger than in the female (see Fig. 187 below).

The caudal ramus (Fig. 177) is relatively shorter than in the female, 132 μ long, 58 μ wide basally, 54 μ in the middle, and 46 μ distally; thus, taking the middle width, the ramus is about 2.4 times longer than wide. The armature of the ramus is like that of the female.

The rostral area is similar to that in the female.

The first antenna is generally like that of the female, but as in the previous species shows an additional seta on the third and fourth segments, the formula being 4, 15, 7, 4, 4 + 1 aesthete, 2 + 1 aesthete, and 7 +1 aesthete.

The second antenna is similar to that of the female.

The labrum (Fig. 178) shows certain differences in details of the spinules and teeth. The number of large teeth at either side of the transverse row appears to be somewhat variable (see Figure 179 of these teeth in another male). There are two diagonal lines of very small refractile points (spinules ?) on each side of the ventral surface of the labrum. The metastomal areas (Fig. 178) are ornamented as indicated in the figure. (In the specimen from which Figure 178 was drawn, the two groups of tooth-like spines on the left side, indicated by broken lines, were missing and presumably broken off.)

The mandible resembles that of the female, but the teeth on the largest element appear to be more pointed (see Fig. 180). The paragnath (Fig. 181) is similar to that of the female, but has a protuberance on the inner margin, which in the female is regular. The first maxilla (Fig. 182) appears to be shorter and less slender than in the female, and, although the long spines and setae are much like those in the opposite sex, there is an additional row of short spinules on the inner margin. The second maxilla (Fig. 183) shows the stout inner element on the second segment here replaced by a strongly sclerotized, rather blunt, claw-like element lacking an articulation with the segment.

The maxilliped (Fig. 184) has a single long seta on the first segment. The second segment has its proximal inner angle greatly expanded. The length of this segment along the outer margin is 224 μ, its greatest length from the distal end to the tip of the inner expansion is 260 μ, and its greatest width is 189 μ. There are three rows of fairly stout spines along the inner surface, in addition to the usual two setae. The third segment is very short and unarmed. The fourth segment forms part of a long recurved claw 270 μ in length (measured along its axis and not along the curvature), bearing near its

base a small seta on the posterior side, and a spinous process and a minute setule on the inner curvature. The ventral surface between the bases of the maxillipeds (Fig. 185) does not show a transverse line. The region between the maxillipeds and the first pair of legs is unmodified as in the female.

Leg 1 lacks the inner spine on the basis (Fig. 186). Otherwise legs 1–4 have a spine and setal formula like that of the female. The sclerotization of the legs, illustrated in the endopod of leg 4 (Fig. 187), seems to be stronger than in the female. (This may be an individual difference, however, since only one male was dissected.)

Leg 5 (Fig. 188) has a free segment which is not broadened distally as in the female, its greatest dimensions being 173 × 73 μ. Its armature is like that of the female.

Leg 6 (Fig. 189) consists of a ventral flap on the posterior part of the genital segment, bearing a strong spine 51 μ in length. In dorsal view the sixth leg is completely hidden except for the tip of the spine.

The color in life is similar to that of the female.

Remarks on its biology.—H. kombensis was always found in burrows in company with other species of *Hemicyclops*, once with *H. carinifer* and three times with both *H. diremptus* and *H. carinifer*.

Relationship to other species.—H. kombensis is included in the group of species having four setae on the basal segment of the first antenna. It may be compared only with the male of *H. leggii* (Thompson and Scott, 1903), since the female of that species remains unknown. The male of *H. leggii*, however, differs in having nearly quadrate caudal rami and in having two setae on the basal segment of the maxilliped. *H. dilatatus* Shen and Bai, 1956, has a "squarish" genital segment in the female. *H. australis* Nicholls, 1944, has two setae on the basal segment of the male maxilliped and the caudal ramus is almost quadrate. *H. indicus* Sewell, 1949, has a genital segment which is very slightly wider than long and the caudal rami are but little longer than broad. In *H. purpureus* Boeck, 1873, as figured by Sars (1917), the fifth leg in the female is not markedly expanded distally and the caudal rami are relatively shorter than in *H. kombensis*. *H. thysanotus* Wilson, 1935, shows lateral expansions in the anterior part of the genital segment and the form of the fifth leg is different from that in the species from Madagascar. In *H. aberdonensis* (T. and A. Scott, 1892) the genital segment is much wider than long, and there are two setae on the basal segment of the male maxilliped. In *H. thompsoni* (Canu, 1888) the genital segment, though elongate, is expanded in its extreme anterior part. *H. tamilensis* (Thompson and Scott, 1903) has in the female broad lateral expansions on the genital segment, and short, almost quadrate caudal rami. In the female of *H. bacescui* (Serban, 1956) the caudal rami are two times longer than wide, the inner spine on the basis of leg 1 is strongly denticulated (Stock, 1959), and the lateral margins of the genital segment are not almost parallel as in *H. kombensis*. *H. visendus* Humes, Cressey, and Gooding, 1958, shows in the female a genital segment somewhat resembling that of *H. kombensis* but which has a pair of dorsolateral ridges; the caudal ramus is only 1.7 times longer than wide; the third segment of the second antenna bears spinules and setae of a different form than in the species from Madagascar; and the free segment of the fifth leg is oval rather than petal-like in outline. The inner side of the second segment of the male maxilliped of *H. visendus* is broadly inflated rather than angularly produced as in *H. kombensis*.

Hemicyclops biflagellatus[1] n. sp.

Pls. XXVII–XXXI; Pl. XXXII, figs. 221–222

Type material.—24 females and 6 males from water in burrows of unknown origin 3–4 cm in diameter and about 50 cm deep in intertidal muddy sand at Ampassipohe, on the southern shore of the bay of Ambato-

[1] The specific name *biflagellatus*, a combination from Latin *bis* = twice and *flagellum* = a whip, refers to the two setiform processes on the segment of leg 5 in the female.

zavavy, Nosy Bé, Madagascar. Collected by A. G. Humes May 11, 1964. Holotype female, allotype, and 22 paratypes (19 females and 3 males) deposited in the United States National Museum, Washington; one paratypic female in the Museum of Comparative Zoology, Cambridge, Mass.; and the remaining paratypes in the author's collection.

Female.—The length of the body (excluding the setae on the caudal rami) is 1.63 mm (1.51–1.80 mm) and the greatest width (in the cephalosome, although in some specimens the segment of leg 2 may be expanded laterally so that its width is slightly greater) is 0.56 mm (0.51–0.61 mm), based on 5 individuals. The prosome is not much broadened, and somewhat longer than the urosome, the ratio being about 1.46 : 1 (Fig. 190). In dorsal aspect the epimera of the segments of legs 1–4 are conspicuously angulate. The segment bearing the fifth legs has a posterior transverse ridge, and bears a pair of prominent posterolateral recurved setiform processes about 100 μ long, with delicate hyaline lateral hairs (?). These processes are perhaps true setae, but an articulation could not be established with certainty. A very narrow intersegmental selerite, more evident in a ventral view, occurs between the first two segments of the urosome. The genital segment (Fig. 191) is elongated, with two rounded lateral wings in its anterior fourth and with the sides of the posterior three-fourths subparallel and only very slightly swollen. An extremely indistinct transverse indication of subdivision occurs internally near the middle of the segment in some specimens. The genital segment measures 294 μ in dorsal length; its width at the anterior lateral expansions is 270 μ, and in the posterior third 167 μ.

The egg sacs are attached dorsolaterally on the two expansions of the genital segment, the actual attachment being covered by a dorsal flange (Fig. 192). Near the point of attachment there are two strongly sclerotized spine-like processes each about 6 μ in length. Each egg sac (Fig. 190) is elongated, about 519 $\times$ 170 μ, and contains numerous small eggs.

The three postgenital segments measure, respectively, 122 $\times$ 143, 84 $\times$ 130, and 78 $\times$ 108 μ. There is no apparent anal operculum. The anal segment bears on its dorsal and ventral surfaces fine hairs, as indicated in the figure. The caudal rami are inserted dorsally and the posterior ventral border of the segment below each ramus bears an outer row of minute spinules and an inner submarginal row of prominent spinules (the longest about 15 μ in length), as shown in Figure 193.

The dorsal surface of the prosome and the dorsal and ventral surfaces of the urosome bear minute hairs and refractile points.

The caudal ramus (Fig. 193) is moderately elongated, 100 μ in length, 41 μ wide just proximal to the lateral seta and 35 μ wide distal to that seta. Taking the width as 41 μ, the ramus is 2.44 times longer than wide. A minute hyaline hair arises on the outer basal margin. The lateral seta (52 μ long) and the outermost terminal seta (90 μ long) are both composed of a basal shaft and a distal flagelliform part. The dorsal seta is 200 μ long and bears a few lateral hairs. The innermost terminal seta is 227 μ in length and bears lateral spinules, those on the inner side being slightly better developed. The inner long terminal seta is 746 μ and the outer one 407 μ in length, both bearing lateral hairs (see Fig. 190). The four terminal setae are inserted somewhat dorsally and the resulting terminal ventral flange on the ramus bears a row of minute spinules. Along the inner margin of the ramus there is a row of very slender setules. Both the dorsal and ventral surfaces of the ramus bear scattered hyaline hairs.

The rostral region (Fig. 194) is well defined and bears a pair of setules and pairs of small hairs as indicated.

The first antenna (Fig. 195) is about 410 μ long, 7-segmented, the segments, beginning at the base, 15, 54, 49, 85, 58, 54, and 52 μ in length (measured along their non-setiferous margins). The armature is 4, 15, 6, 3, 4 + 1 aesthete, 2 + 1 aesthete, and

7 + 1 aesthete (the same formula as in *H. axiophilus*, *H. amplicaudatus*, *H. diremptus*, and *H. kombensis*). A few of the setae on the second segment show very short lateral hairs. On the distal posteroventral surface of this segment there are a few short rows of minute refractile points. Certain setae bear long lateral hairs as in *H. kombensis*.

The second antenna (Fig. 196) is 4-segmented, with the third segment produced on the inner distal corner where it bears four elements: proximally a slender posterior seta, more distally a long recurved seta (which resembles the four long terminal recurved setae on the last segment), and distally two unequal recurved spines, both bearing subterminal setules and the longer one a row of prominent spinules. The fourth segment is nearly quadrate, 33 × 30 μ, and bears seven setae much like those in *H. kombensis*.

The labrum (Fig. 197), in addition to ornamentation suggesting that in *H. kombensis*, shows a crescentic row of long hyaline setules, with the surface posterior to this row bearing conspicuous obtuse scales. The metastomal areas have a complex ornamentation, as shown in Figure 198.

The mandible (Fig. 199) has two stout elements and two well-developed setae with lateral hairs. The paragnath (Fig. 200) is a moderately elongated lobe bearing long hairs (shorter at the tip) and a row of small spinules as indicated. The first maxilla (Fig. 201) is in general similar to that of *H. kombensis*. The second maxilla (Fig. 202) also resembles in major features that of *H. kombensis*. The maxilliped (Fig. 203) is also much like that of *H. kombensis*, but the second segment is relatively longer and more slender, and the setae (including the two terminal claw-like setae) tend to be relatively longer. From near the base of the shorter claw-like seta there arises a setiform process without clear articulation. Between the bases of the maxillipeds there is a conspicuous ventral transverse sclerotization as shown in Figure 198.

The area between the maxillipeds and the first pair of legs is without conspicuous features.

The armature of legs 1–4 (Figs. 204, 205, 206, and 208) is as follows:

P1	protopod	0:1	1:1	exp	1:0	1:1	I,I,6
				end	0:1	0:1	I,5
P2	protopod	0:1	1:0	exp	1:0	1:1	II,7
				end	0:1	0:2	I,II,3
P3	protopod	0:1	1:0	exp	1:0	1:1	II,I,6
				end	0:1	0:2	I,II,3
P4	protopod	0:1	1:0	exp	1:0	1:1	I,7
				end	0:1	0:2	I,II,2

This formula is somewhat different from that of *H. axiophilus*, the third exopod segment of leg 1 having two spines and the same segment in leg 3 having three spines. In leg 1 the inner spine on the basis is 105 μ in length, with short lateral spinules and with a blunt tip. The margin of the basis medial to this spine is rounded and smooth except for a tooth-like process near the base of the spine. In legs 2–4 this inner area of the basis bears a row of marginal hairs and a group of slender hyaline spinules on its anterior surface. The ventral margin of the intercoxal plate of leg 1 bears on each side rows of long hairs, but in legs 2–4 these hairs are replaced by spinules. The outer margin of the coxa of leg 4 lacks the long spinules seen on legs 1–3, but a row of slender spinules occurs on the outer posterior margin. In leg 3 the distalmost spine on the last segment of the exopod is distinctly spine-like rather than almost setiform as in *H. kombensis*. (An abnormal second segment of the exopod of leg 3, with two outer spines instead of one, is shown in Fig. 207.) On the last segment of the endopod of leg 4 the inner two elements are different from the outer three: the inner one being almost spine-like with lateral hairs basally and with a bilateral fringe of spinules in the distal three-fourths, the outer one being setiform with lateral hairs.

Leg 5 (Fig. 209) has a free segment which is somewhat constricted basally, broadened in the middle, and narrowed beyond the first outer spine. Its greatest length is 120 μ (91 μ along the outer edge to the base of the first spine and 94 μ along

the inner edge), and its greatest width is 56 μ. The ratio of greatest length to width is 2.14 : 1. There are rows of prominent spinules on both outer and inner margins. The three spines are 63, 59, and 71 μ in length, respectively, from outer to inner. The first few inner lateral spinules on the innermost spine are unusually long. The outermost spine seems to lack outer spinules. The seta is 93 μ long and bears a few lateral hairs. The basal area of leg 5 suggests a discrete segment; it is armed with a plumose seta about 100 μ in length and a group of outer spinules.

Leg 6 is apparently absent.

The color in living specimens, in transmitted light, is slightly opaque, with reddish orange globules in the prosome, the eye dark red, the ovary gray, the egg sacs dark reddish orange.

Male.—The length of the body (not including the setae on the caudal rami) is 1.34 mm (1.25–1.46 mm) and the greatest width is 0.45 mm (0.41–0.50 mm), based on 5 individuals. The prosome is less expanded than in the female (Fig. 210). The ratio of the length of the prosome to that of the urosome is about the same as that in the female. The segment of leg 5 lacks the two setiform processes seen in the female. The genital segment (Fig. 211) is wider than long, 148 × 178 μ, with gently rounded lateral margins.

The four postgenital segments measure, respectively, 108 × 103, 95 × 101, 62 × 98, and 54 × 89 μ.

As in the female, the prosome and urosome bear hairs and refractile points.

The caudal ramus is similar to that of the female, but is relatively shorter, the greatest length being 80 μ, the width just proximal to the lateral seta 35 μ, and the width distal to that seta 31 μ. Taking the width as 35 μ, the ramus is 2.29 times longer than wide.

The spermatophore (Fig. 212), as seen attached to the female, is pyriform, 68 μ long (including the slender neck of 6 μ) and 40 μ wide.

The rostral area is like that of the female.

The first antenna resembles that of the female, but, as in previous species, has an additional seta on the third and fourth segments, so that the formula is 4, 15, 7, 4, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete.

The second antenna is similar to that of the female.

The labrum (Fig. 213) lacks the crescentic row of hyaline spinules, and the medial posteroventral surface has numerous scales and spinules, as shown in the figure. The metastomal areas (Fig. 214) are ornamented as indicated in the figure.

The mandible is like that in the female. The paragnath (Fig. 214) resembles that of the female, but seems to be somewhat more slender. The first maxilla is similar to that of the female. The second maxilla (Fig. 215) shows the stout inner element on the second segment here replaced by a strongly sclerotized, rather blunt, claw-like structure, sometimes pale yellowish in color, which lacks an articulation with the segment.

The maxilliped (Fig. 216) has a single long seta on the first segment. The second segment has its proximal inner angle expanded and rounded; the length of this segment along the outer margin is 137 μ, its greatest length from the distal end to the tip of the inner expansion is 173 μ, and its greatest width is 115 μ. There are three rows of fairly stout spines along the inner margin, in addition to the usual two setae. The third segment is very short and unarmed. The fourth segment forms part of the long recurved claw 189 μ in length (measured along its axis and not along its curvature), bearing near its base on the posterior surface a small seta 18 μ long, and on its inner curvature a spinous process 25 μ long and a minute setule 5 μ long. The ventral surface of the cephalosome between the bases of the maxillipeds (Fig. 217) shows only an incomplete transverse line, instead of the readily visible sclerotization seen in the female.

Leg 1 lacks the inner spine on the basis (Fig. 218). Otherwise legs 1–4 show the same spine and setal formula as in the fe-

male. The last endopod segments of legs 2 and 3 (Figs. 219 and 220) show the three terminal processes reduced and blunt, in contrast to their acute spiniform condition in the female.

Leg 5 (Fig. 221) has a free segment which is relatively longer and more slender than in the female. Its greatest length is 116 μ (81 μ along the outer edge to the base of the first spine and 93 μ along the inner edge) and its greatest width is 44 μ. The armature resembles in major respects that of the female, although the outermost spine has spinules along both sides. The basal area of leg 5 does not seem to show a clear separation from the body.

Leg 6 (Fig. 222) consists of a ventral flap on the posterior part of the genital segment, bearing a strong spine 44 μ in length. In a dorsal view of the animal this spine projects posterolaterally beyond the edge of the segment.

The color in life resembles that of the female.

Remarks on its biology.—*H. biflagellatus* was collected on only one occasion, and then from burrows which also contained *H. diremptus* and *H. carinifer*.

Relationship to other species.—This species seems to be unique among the previously described species of the genus in having two posterolateral setiform processes on the segment of leg 5. Otherwise, it resembles *H. thysanotus* Wilson, 1935, in certain respects. However, in the female of *H. thysanotus* the inner spine on the basis of leg 1 is recurved and rather blunt instead of straight, and in the male the form of the maxilliped is rather different from that of the Madagascar species. *H. biflagellatus* is unlike *H. leggii* (Thompson and Scott, 1903), of which only the male is known; in this species the caudal rami are nearly quadrate and the basal segment of the male maxilliped has two setae. *H. bacescui* (Şerban, 1956) has, in the female, less prominent expansions on the genital segment and the inner spine on the basis of leg 1 has strong denticulations. *H. purpureus* Boeck, 1873, has, in the female, a broader distal segment in leg 5 and shorter caudal rami, and the inner distal corner of the third segment of the second antenna is not prolonged. *H. thompsoni* (Canu, 1888) has a broad distal segment of leg 5 in the female.

The following species also has a pair of setiform processes on the segment of leg 5, but may be readily distinguished from *H. biflagellatus* as pointed out below.

Hemicyclops acanthosquillae[1] n. sp.

Pl. XXXII, figs. 223–227; Pls. XXXIII–XXXVI

Type material.—8 females and 5 males washed from the bodies of two stomatopods, *Acanthosquilla* sp., dug from intertidal sand at Antsakoabe, on the northwestern shore of Nosy Bé, Madagascar. Collected by A. G. Humes July 12, 1964. Holotype female, allotype, and 8 paratypes (5 females and 3 males) deposited in the United States National Museum, Washington; one paratypic female in the Museum of Comparative Zoology, Cambridge, Mass.; and the remaining paratypes in the author's collection.

Female.—The length of the body (not including the setae on the caudal rami) is 2.24 mm (2.00–2.44 mm) and the greatest width (taken at the level of the segment bearing leg 2) is 0.71 mm (0.68–0.80 mm), based on 5 individuals. The prosome is moderately broadened and of about the same length as the urosome (Fig. 223). In dorsal aspect the epimera of the segments of legs 1–4 are angulate posterolaterally. The segment bearing the fifth legs is rounded laterally and bears a pair of posterolateral smooth setiform processes about 72 μ in length (Figs. 224 and 225). (These resemble somewhat the two setiform processes described in the preceding species.) Medial to the two processes there is a pair of minute hyaline setules (hairs ?) about 8 μ long. An intersegmental sclerite may be seen ventrally between the first two urosomal segments. The genital segment (Fig. 224) is

[1] The specific name *acanthosquillae* is taken from the generic name of the crustacean upon whose body the copepod was found.

greatly elongated. In dorsal view it shows two pronounced lateral swellings in its anterior fifth, the remaining portion of the segment having the sides nearly parallel. Dorsally, just anterior to the midregion, there are four longitudinally oblique sclerotizations. The segment measures 486 μ in length; its width at the level of the two swellings is 289 μ, and in the posterior part 224 μ.

The egg sacs are attached slightly dorsally on the lateral swellings of the genital segment, between dorsal and ventral flanges. Each egg sac is elongated (Fig. 223), about 730 $\times$ 235 μ, and contains many small eggs, each about 53 μ in diameter.

The three postgenital segments measure, respectively, 243 $\times$ 205, 159 $\times$ 159, and 100 $\times$ 135 μ. There is no evident anal operculum. The anal segment is provided ventrally on each side along its posterior margin with an outer row of minute spinules and an inner row of spines (see Fig. 226). The dorsal surface of the urosome bears minute refractile points and hairs as shown in Figure 224.

The caudal ramus (Fig. 226) measures 116 $\times$ 54 μ (2.15 times longer than wide). All six setae are inserted somewhat dorsally. There is a minute hyaline hair on the basal outer margin. The lateral seta (58 μ long) and the outermost terminal seta (103 μ long) are both composed of a distinct basal shaft and a distal flagelliform part. The sparsely haired dorsal seta is 95 μ in length. The innermost terminal seta is 282 μ in length and bears lateral spinules. The inner long terminal seta is 1017 μ and the outer one 542 μ in length, both bearing lateral hairs (see Fig. 223). The posterior end of the ramus is prolonged ventrally to form a flange bearing a row of minute spinules and, near the base of the innermost terminal seta, a row of larger spinules. The distal half of the inner margin of the ramus bears a row of very slender spinules.

The rostral area (Fig. 227) is well defined and bears a pair of setules.

The first antenna (Fig. 228) is about 441 μ long, 7-segmented, the segments, beginning at the base, being 15, 68, 49, 94, 59, 58, and 54 μ in length (measured along their non-setiferous margins). The armature is similar to that of *H. biflagellatus*.

The second antenna (Figs. 229 and 230) is 4-segmented, with the third segment much produced on the inner distal corner, where it bears four elements: proximally a slender seta, more distally a stout recurved seta, and terminally two recurved unequal spines, both provided with subterminal setules and the longer one having a row of spinules. The fourth segment is quadrate, 23 $\times$ 23 μ, and bears the usual seven setae. The convex inner area of the second segment bears on its posterior surface numerous scale-like protuberances, and the concave inner area of the third segment bears also on its posterior surface short spine-like knobs (see Fig. 230).

The labrum (Fig. 231) has a group of broad irregular ventromedial lobes, in addition to the other ornamentation shown in the figure. The metastomal areas have a complex ornamentation, as indicated in Figure 232.

The mandible (Fig. 233) has the usual two stout elements and two well-developed setae with lateral spinules. The paragnath (Fig. 234) is a moderately elongated lobe with hairs and short spinules as indicated in the figure. The first maxilla (Fig. 235) resembles in major respects that of *H. biflagellatus*. The second maxilla (Fig. 236) is similar to that of the preceding species. The maxilliped (Fig. 237) also resembles in general structure that of the preceding species, but there is a greater number of small hyaline setae near the bases of the two terminal claw-like setae. There is a conspicuous ventral transverse sclerotization between the bases of the maxillipeds (see Fig. 232) as in *H. biflagellatus*.

The area between the maxillipeds and the first pair of legs lacks outstanding features.

The armature of legs 1–4 (Figs. 238, 240, 242, and 243) is similar to that of *H. axiophilus*. In leg 1 the inner spine on the basis is 52 μ in length, with short truncated lateral spinules, giving the edges the ap-

pearance of a saw blade (Fig. 239). The margin of the basis medial to this spine is smooth, except for a rather blunt tooth-like process near the base of the spine. In legs 2–4 this inner area of the basis bears a row of marginal hairs and a group of slender hyaline setules on its anterior surface. As in the preceding species, the ventral margin of the intercoxal plate of leg 1 bears hairs, while in legs 2–4 it bears spinules; and the coxa of leg 4 lacks the long slender spinules seen in legs 1–3, instead having a row of spinules on the outer posterior margin. In leg 1 the outer margin of the second segment of the endopod bears only a row of hairs, but in legs 2–4 this margin bears basally a group of small knobs (Fig. 241) followed by the usual hairs. On the last endopod segment of leg 4 the inner two elements are setae, the lateral hairs on the innermost being equal but those on the adjacent seta being longer near the base and shorter on the distal three-fourths of the seta; the fringed inner terminal spine is more than twice as long as either the outer terminal spine or the outer lateral spine.

Leg 5 (Fig. 244) has a free segment which is narrow basally but broadened distally, its greatest dimensions being 142 × 95 μ, with a ratio of length to width of 1.5 : 1. There are rows of long spinules on both outer and inner edges of the segment. The three spines measure 67, 73, and 86 μ in length, respectively, from outer to inner; the seta is 88 μ long. The basal area of the leg suggests a discrete segment and is armed as in the preceding species.

Leg 6 is apparently absent.

The color in living specimens in transmitted light is slightly amber, with the eye red and the egg sacs gray. The spermatophores attached to the female are golden brown.

Male.—The length of the body (not including the setae on the caudal rami) is 1.85 mm (1.79–1.91 mm), and the greatest width is 0.63 mm (0.60–0.66 mm), based on 5 individuals. The prosome is only slightly less expanded than in the female, and is somewhat longer than the urosome (Fig. 245), the ratio being 1.2 : 1. The segment of leg 5 lacks the two setiform processes seen in the female, but instead has dorsally on each side, medial to the seta associated with the leg, a somewhat triangular projection (Figs. 246 and 247). The genital segment (Fig. 246) is about as long as wide, 260 × 271 μ, with gently rounded lateral margins.

The four postgenital segments measure, respectively, 186 × 157, 157 × 130, 108 × 116, and 76 × 116 μ.

The dorsal surface of the urosome bears hairs and refractile points, as indicated in the figure.

The caudal ramus resembles that of the female, but is relatively shorter, the greatest dimensions being 92 × 49 μ. The ratio of length to width is 1.88 : 1.

The spermatophore (Fig. 248), as seen attached ventrally on the genital segment of the female, is somewhat irregularly ovoid. Its greatest dimensions are 124 × 99 μ plus a neck of 13 μ.

The rostral region (Fig. 249) is only slightly less defined than that of the female.

The first antenna resembles that of the female, but, as in previous species, has an additional seta on the third and fourth segments, thus giving the formula of 4, 15, 7, 4, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete.

The second antenna is like that of the female.

The labrum (Fig. 250) has a more complex ornamentation than in the female. The metastomal areas (Fig. 251) are ornamented as shown in the figure.

The mandible resembles that of the female. The paragnath appears to be similar to that of the female, but the notch on the outer edge is less apparent. The first maxilla is like that of the female. The second maxilla (Fig. 252), as in previous species, has the stout inner element on the second segment transformed to form a strongly sclerotized, rather blunt, claw-like structure, having a conspicuous yellowish amber color and lacking an articulation with the segment.

The maxilliped (Fig. 253) has a single long seta on the first segment. The second segment has its proximal inner angle rather acutely expanded. The length of this segment along its outer margin is 197 μ, its greatest length from the distal end to the tip of the inner expansion is 240 μ, and its greatest width is 159 μ. There are three rows of moderately stout but somewhat obtuse spines along the inner surface, plus the usual two setae. The third segment is very short and unarmed. The fourth segment forms part of the long, slightly recurved claw, 235 μ in length (measured along its axis and not along its curvature). The claw bears near the base on its posterior surface a slender seta 35 μ in length, and on its inner curvature a spinous process 28 μ long and a minute setule 10 μ long. The ventral surface of the cephalosome between the bases of the maxillipeds shows only an incomplete transverse line (Fig. 251), as in *H. biflagellatus*.

Leg 1 lacks the inner spine on the basis (Fig. 254) and the spinules in this region are longer and more slender than in the female. Otherwise legs 1–4 have the same spine and setal formula as in the female. The sclerotization of the rami appears to be stronger than in the opposite sex.

Leg 5 (Fig. 255) has an elongated free segment which is relatively much more slender than in the female. Its greatest dimensions are 132 × 57 μ, the ratio of length to width being about 2.3 : 1. The ornamentation resembles that of the female, but the lateral spinules on the three terminal spines are shorter. The basal area of leg 5 does not show a separation from the body. Leg 6 (Fig. 256) consists of a ventral sclerotized flap on the posterior region of the genital segment, bearing an outwardly directed spine 38 μ in length with minute lateral spinules on each side. This spine in dorsal view of the body projects posterolaterally beyond the edge of the genital segment (see Figs. 245 and 246).

The color in life resembles that of the female.

Remarks on its biology.—The two stomatopods from which these copepods were taken appeared in the water seeping into a hole 30 cm deep which had been dug in clean sand. They were quickly placed in a plastic bag with a small amount of sea water. Later a few drops of ethyl alcohol were added, the whole gently agitated, and the copepods recovered from the sediment. There seems to be justification for assuming that these *Hemicyclops* were living on the bodies of the *Acanthosquilla*. This is the first record of a member of the genus *Hemicyclops* occurring on a stomatopod.

Relationship to other species.—*H. acanthosquillae* belongs to the group of *Hemicyclops* species having four setae on the first segment of the first antenna. It possesses several very characteristic features by which it may be distinguished from other members of this group: on the segment of leg 5 in the female a pair of dorsolateral setiform processes and in the male a pair of triangular projections; the form, armature, and ornamentation of the second antenna, especially the greatly produced inner distal corner of the third segment and the very small quadrate fourth segment; the ornamentation of the outer edge of the second segment of the endopods of legs 2–4; and the acute inner proximal expansion of the second segment of the male maxilliped.

H. acanthosquillae bears certain resemblances to *H. biflagellatus*. For example, in the female, the elongated genital segment has anterior lateral expansions and there is a pair of setiform processes on the segment of leg 5. It may be distinguished from *H. biflagellatus*, however, by several readily observable characters, such as the form of the second antenna, the fifth leg, and the male maxilliped.

REMARKS ON THE SPECIES OF *HEMICYCLOPS* FROM MADAGASCAR

Gooding (1960) divided the American species of *Hemicyclops* into two groups on the basis of morphological characters. Later (1963, unpublished thesis), he developed further this concept of groups of species within the genus. Selecting a few typical

characters, the eight known species from Madagascar (comprising the seven described above and *H. visendus*) may be placed in two groups (corresponding to two of Gooding's):

1) those species with the urosome of the adult female having five segments, with four setae on the first segment of the first antenna, with a short terminal segment on the second antenna, and with a sexually dimorphic second maxilla, including:

H. axiophilus n. sp.
H. amplicaudatus n. sp.
H. diremptus n. sp.
H. kombensis n. sp.
H. biflagellatus n. sp.
H. acanthosquillae n. sp.
H. visendus Humes, Cressey, and Gooding, 1958;

2) that species with the urosome of the adult female having six segments, with five setae on the first segment of the first antenna, with an elongate terminal segment on the second antenna, and without sexual dimorphism in the second maxilla:

H. carinifer n. sp.

THE GENUS *HEMICYCLOPS* IN THE INDIAN OCEAN

Five species of *Hemicyclops* have been reported from the Indian Ocean area: *H. indicus* Sewell, 1949, from Nankouri Harbour, Nicobar Islands, in weed-washings; *H. leggii* (Thompson and Scott, 1903) in washings from dredgings, sponges, in the Gulf of Manaar, Ceylon; *H. intermedius* Ummerkutty, 1962, from weed-washings in the Gulf of Manaar, southeastern coast of India; *H. tamilensis* (Thompson and Scott, 1903) in Muttuvaratu pearl oyster washings, Ceylon; and *H. visendus* Humes, Cressey, and Gooding, 1958, from *Upogebia* sp. at Nosy Bé, Madagascar.

In addition, Pillai (1963) has reported *Hemicyclops* sp. from brackish water at Ashtamudi Lake, Quilon, Kerala State, India. The only specimen, a male, is 2.3 mm in length and belongs to the group of species having four setae on the first segment of the first antenna. Its size alone distinguishes it from all six of the species in this group from Madagascar described above. The caudal ramus is nearly three times longer than wide (in *H. amplicaudatus* it is 3.6 times, in *H. axiophilus*, *H. diremptus*, *H. kombensis*, *H. biflagellatus*, and *H. acanthosquillae* it is 2.4 times or less). The male of *H. kombensis* appears to be closest to the Indian specimen, having a length of 2.09 mm and the caudal ramus being 2.4 times longer than wide. In the Indian form, however, the free segment of leg 5 is broader, the genital segment is not constricted anteriorly, and hairs occur along the entire inner border of the caudal ramus.

The question arises whether Pillai's specimen may be one of the five Indian Ocean species mentioned above. This male shows the fourth segment of the first antenna distinctly longer than the second (Pillai's fig. 49), while in *H. indicus* the reverse is true. The free segment of leg 5 is broadened and the second segment of the male maxilliped has its inner side rather angularly expanded proximally, while in *H. visendus* the free segment is elongate and the second segment of the maxilliped has its inner side broadly expanded. The caudal rami are nearly three times longer than wide and the first segment of the male maxilliped has one seta, while in *H. leggii* the caudal rami are nearly quadrate and the first segment of the maxilliped has two setae. The male of *H. tamilensis* is unknown, but the female of this Ceylonese species has nearly quadrate caudal rami, and it is perhaps safe to assume for the present that *H. tamilensis* and Pillai's single male are distinct.

Only the female of *H. intermedius* is known. It belongs to the group of *Hemicyclops* species having four setae on the first segment of the first antenna. It appears to be distinct from all six new species in this group described above. In these the caudal ramus is two or more times longer than wide, while in *H. intermedius* it is quadrate; the contour of the genital segment in dorsal view is different from that in *H. intermedius*; the inner distal corner of the third segment

of the second antenna is produced, while in *H. intermedius* this region is rounded; and the armature of the four legs is somewhat different than in *H. intermedius*, where, for example, the formula for the third exopod segment of the first leg is III,I,4.

It is difficult to compare *H. intermedius* and Pillai's *Hemicyclops* sp., since the corresponding sexes are not known. These two copepods seem to be distinct, however, since in the male *Hemicyclops* sp. the caudal rami are nearly three times longer than wide, the inner distal corner of the third segment of the second antenna is produced, and the armature of the third exopod segment of the first leg is I,7.

Twelve described species and one unnamed form of *Hemicyclops* are now known from the Indian Ocean area: *H. indicus* from the Nicobar Islands, *H. leggii* and *H. tamilensis* from Ceylon, *H. intermedius* and *H.* sp. from India, and *H. axiophilus*, *H. amplicaudatus*, *H. carinifer*, *H. diremptus*, *H. kombensis*, *H. biflagellatus*, *H. acanthosquillae*, and *H. visendus* from Madagascar.

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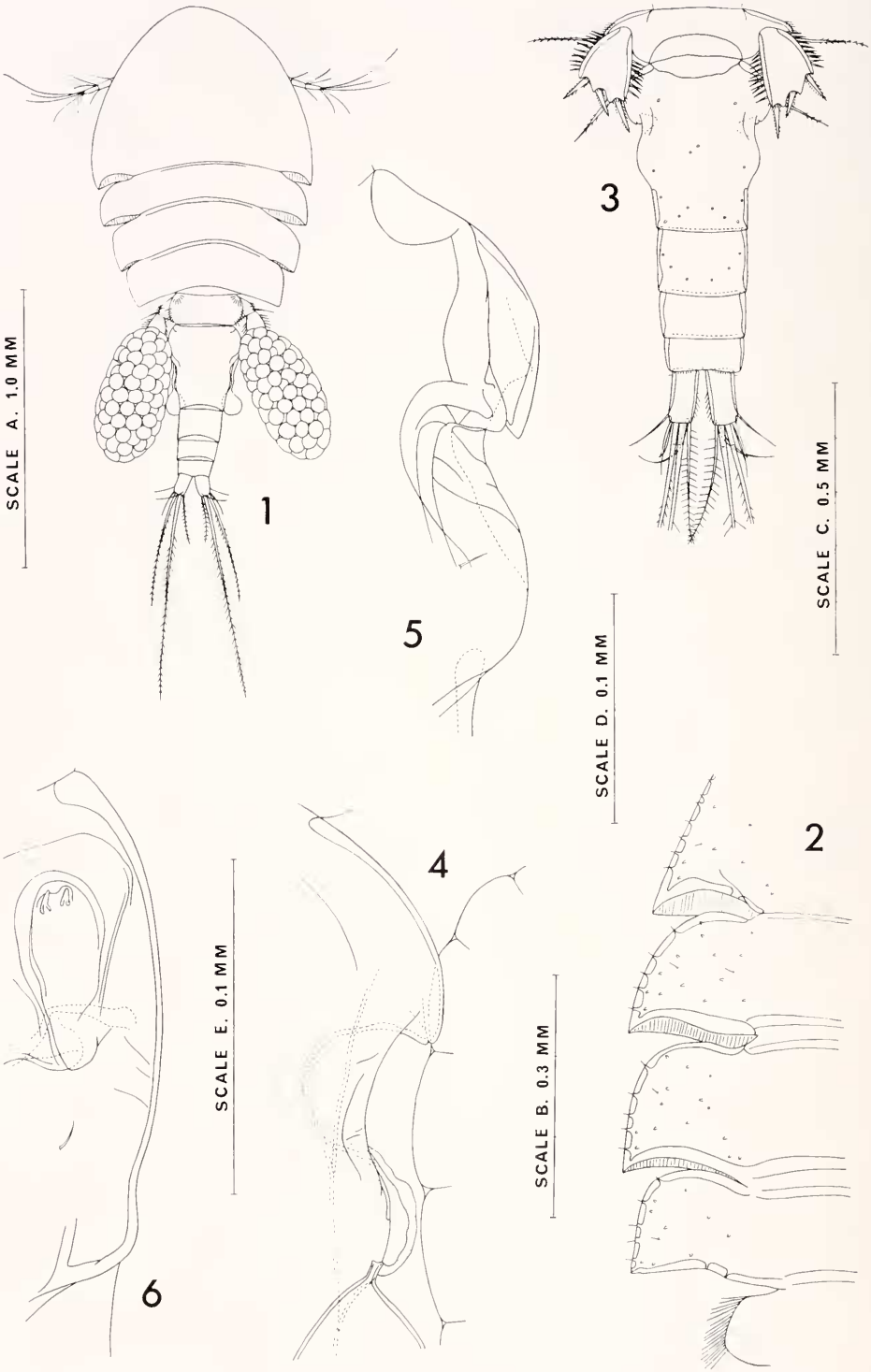
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SCALE C. 0.5 MM
SCALE D. 0.1 MM
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SCALE B. 0.3 MM
SCALE E. 0.1 MM
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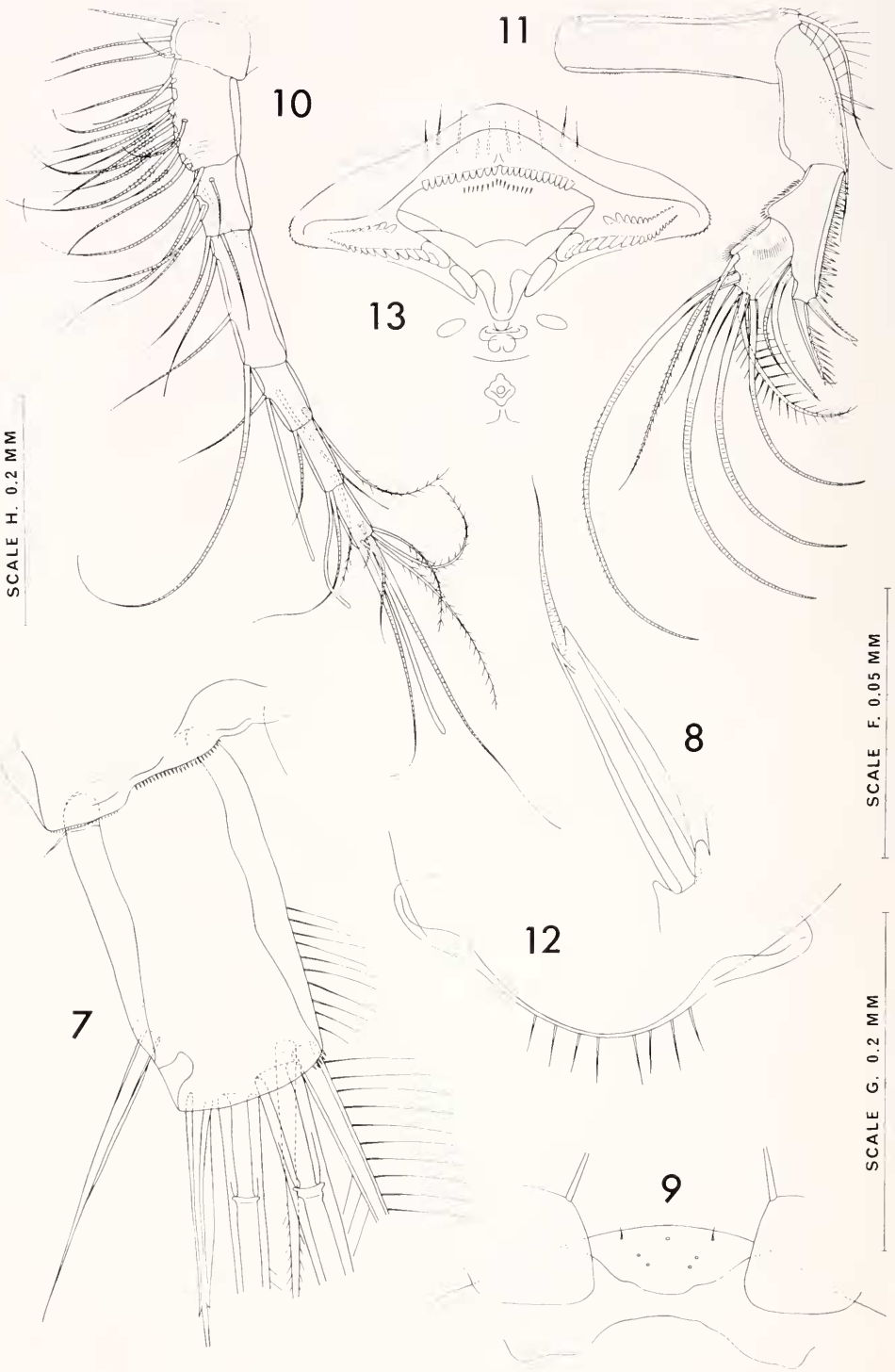
EXPLANATION OF FIGURES

All figures were drown with the aid of a camero lucido. The letter ofter each figure refers ta the scole at which it wos drawn.

Plate I

Hemicyclops axiophilus n. sp., female

Fig. 1. Body, dorsol (A).
Fig. 2. Edges of somites of legs 1–5, dorsol (B).
Fig. 3. Urosome, ventral (C).
Fig. 4. Port of edge of genital segment showing oreos of attachment of egg soc and spermatophore, ventral (D).
Fig. 5. Port of edge of genital segment, dorsal (D).
Fig. 6. Same, loterol (E).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SCALE H. 0.2 MM
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SCALE F. 0.05 MM
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SCALE G. 0.2 MM
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Plate II

Hemicyclops axiophilus n. sp., female (continued)

Fig. 7. Caudal ramus, ventral (E).
Fig. 8. Outermost terminal seta on caudal ramus, dorsal (F).
Fig. 9. Rostral area, ventral (G).
Fig. 10. First antenna, anterodorsal (H).
Fig. 11. Second antenna, anterior or ventral (G).
Fig. 12. Edge of labrum, anterior and dorsal (E).
Fig. 13. Posterior surface of labrum, pushed forward (E).

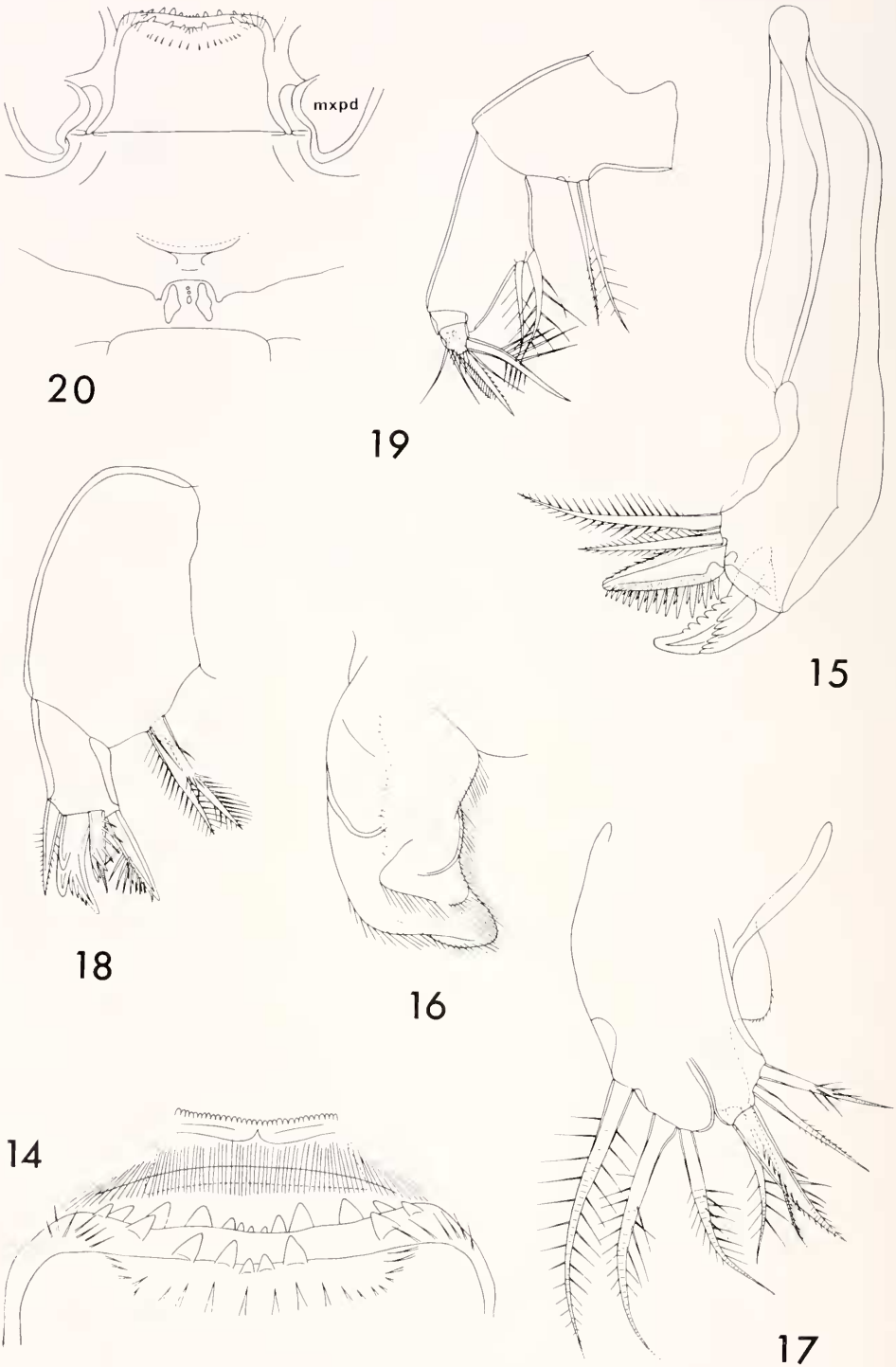
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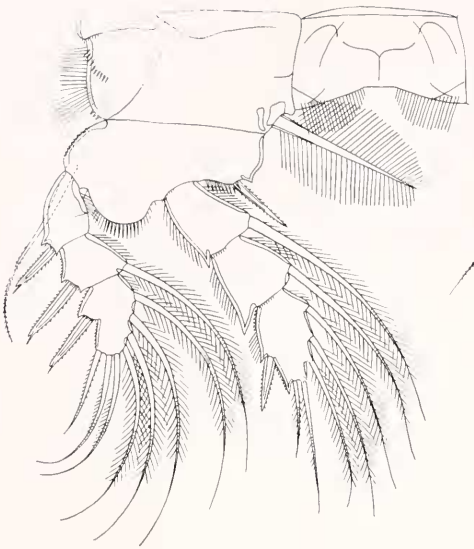
Plate III

Hemicyclaps axiaphilus n. sp., female (continued)

Fig. 14. Metastamal areas, ventral (E).
Fig. 15. Mandible, anteriar and dorsal (E).
Fig. 16. Paragnath, anteriar (E).
Fig. 17. First maxilla, posterior (E).
Fig. 18. Secand maxilla, posteriar (G).
Fig. 19. Maxilliped, anteriar ar dorsal (G).
Fig. 20. Regian between maxillipeds and leg 1, ventral (H).



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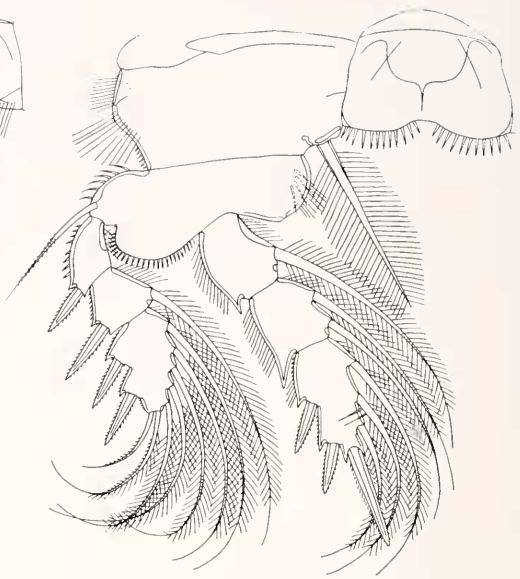

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Plate IV

Hemicyclops axiophilus n. sp., female (continued)

Fig. 21. Leg 1, anterior (H).
Fig. 22. Leg 2, posterior (H).
Fig. 23. Leg 3, posterior (H).
Fig. 24. Leg 4, posterior (H).

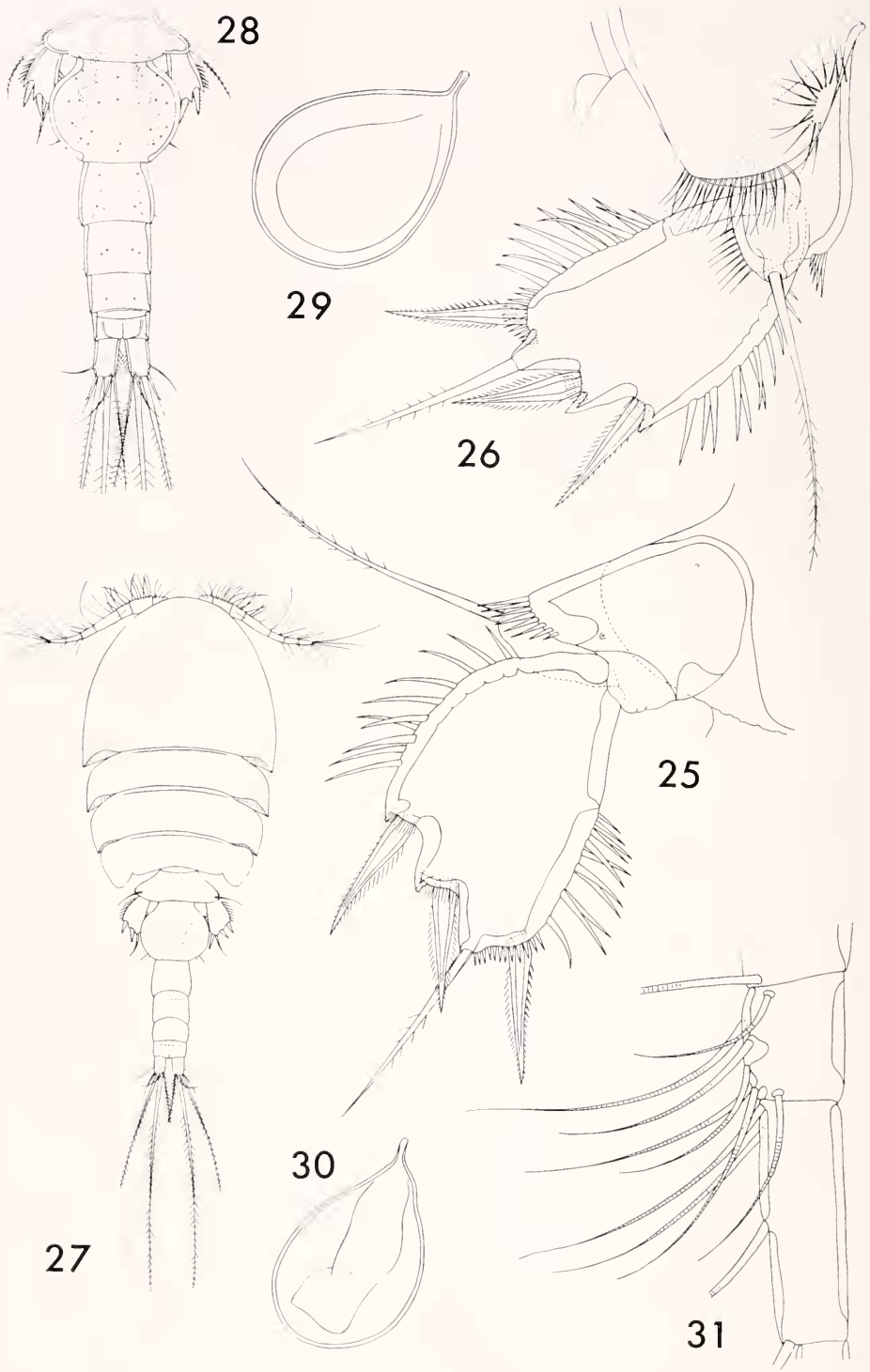
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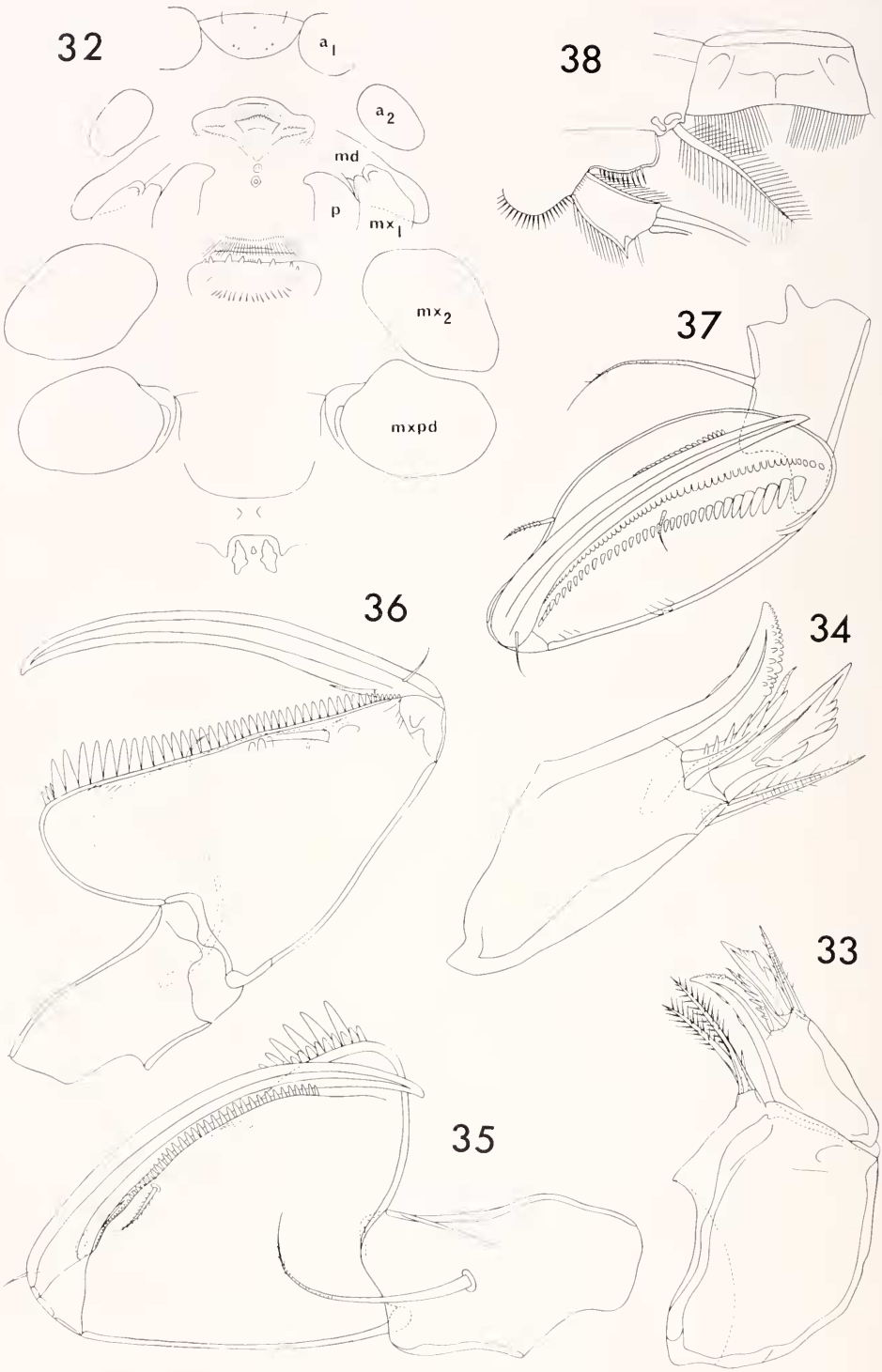
Plate V

Hemicyclops axiophilus n. sp., female (continued)

Fig. 25. Leg 5, ventral (D).
Fig. 26. Leg 5, dorsal (D).

Hemicyclops axiophilus n. sp., male

Fig. 27. Body, dorsal (A).
Fig. 28. Urosome, dorsal (C).
Fig. 29. Spermotophore attached to female (D).
Fig. 30. Spermatophore inside male (D).
Fig. 31. Segments 3 and 4 of first antenna, anterodorsal (D).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a1
a2
md
p
mx1
mx2
mxpd
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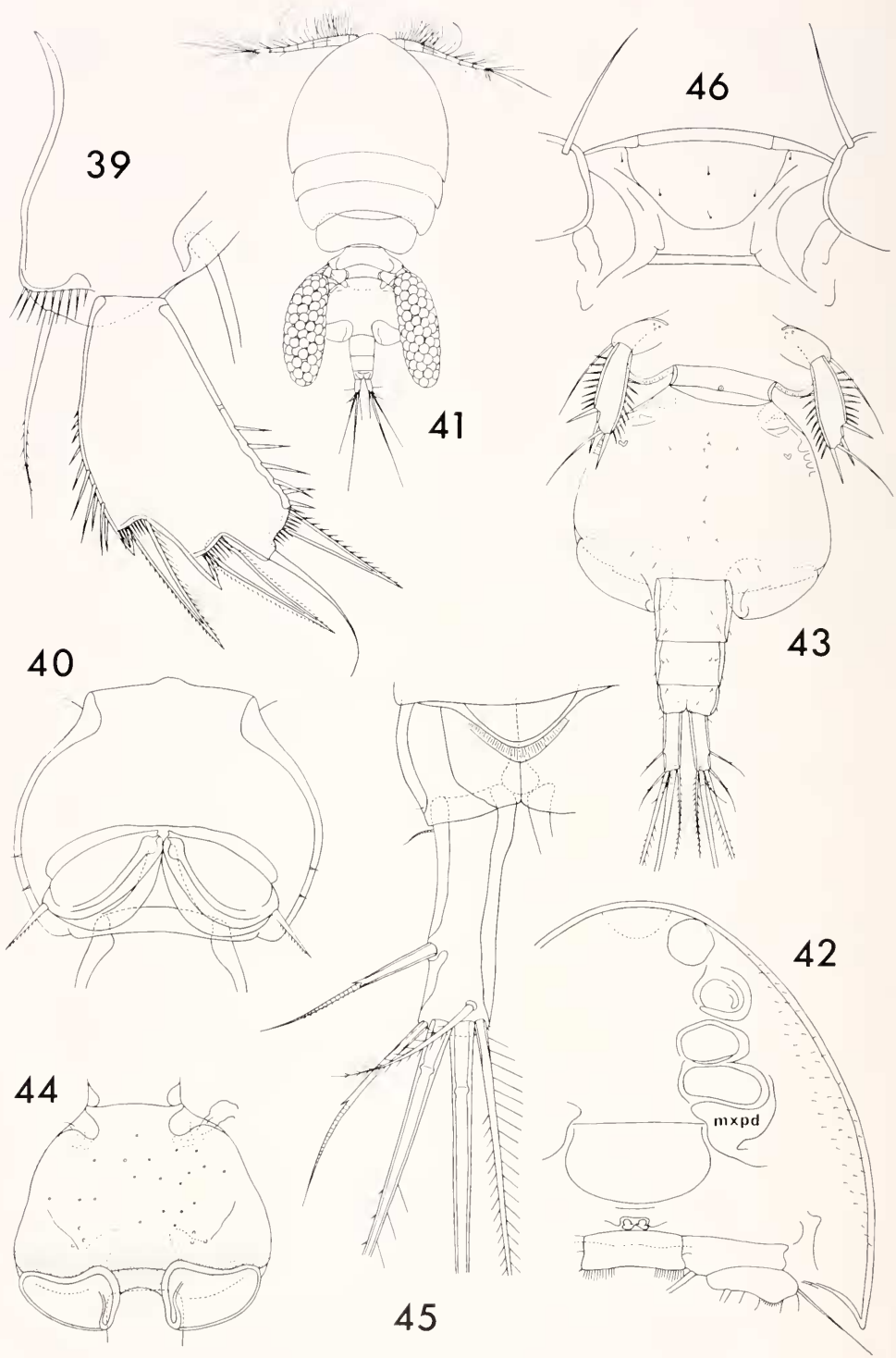
Plate VI

Hemicyclops axiaphilus n. sp., male (continued)

Fig. 32. Part of cephalosome, ventral (H).
Fig. 33. Second maxilla, posterior (G).
Fig. 34. Distal segment of second maxilla, posterior (E).
Fig. 35. Maxilliped, anterior (dorsal of large segment and claw) (G).
Fig. 36. Maxilliped, posterior (ventral of large segment and claw) (G).
Fig. 37. Maxilliped, inner surface (G).
Fig. 38. Detail of part of leg 1, posterior (H).

Abbreviations

a_1, first antenna	mx_1, first maxilla
a_2, second antenna	mx_2, second maxilla
md, mandible	mxpd, maxilliped
p, paragnath	p_1, leg 1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mxpd
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Plate VII

Hemicyclops axiophilus n. sp., male (continued)

Fig. 39. Leg 5, ventral (D).
Fig. 40. Genital segment showing leg 6, ventral (H).

Hemicyclops amplicaudatus n. sp., female

Fig. 41. Body, dorsal (A).
Fig. 42. Port of cepholosome, ventral (B).
Fig. 43. Urosome, ventral (B).
Fig. 44. Genital segment, dorsal (B).
Fig. 45. Caudal ramus and port of anal segment, dorsal (E).
Fig. 46. Rostral area, ventral (D).

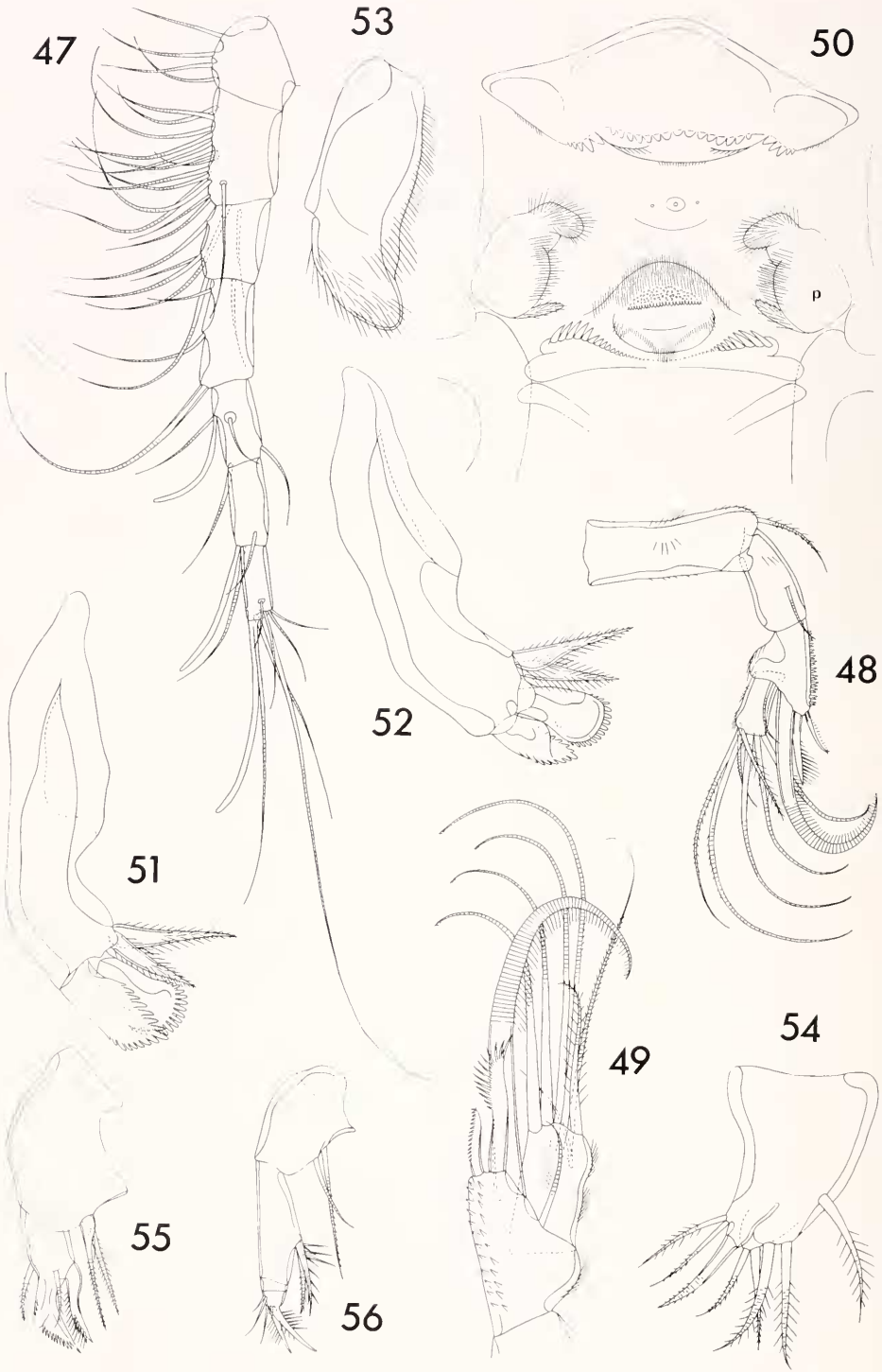
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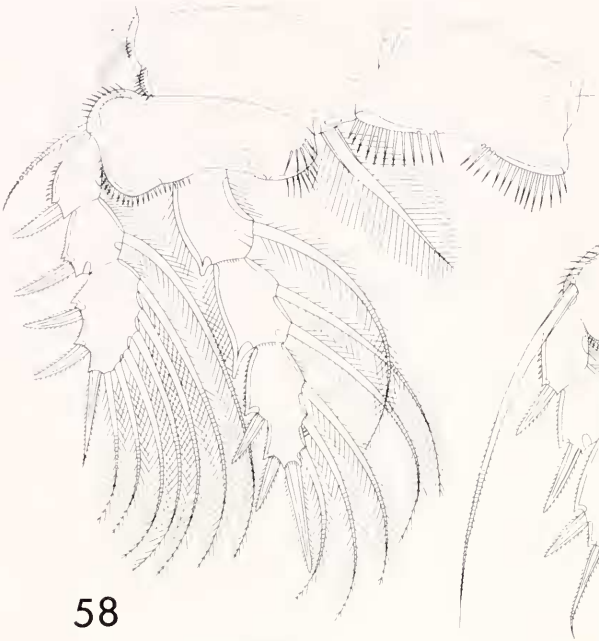
Plate VIII

Hemicyclops amplicaudatus n. sp., female (continued)

Fig. 47. First antenna, ventral (G).
Fig. 48. Second antenna, posterior (G).
Fig. 49. Last two segments of second antenna, posterior (E).
Fig. 50. Oral area, ventral (E).
Fig. 51. Mandible, ventral (E).
Fig. 52. Mandible, dorsal (E).
Fig. 53. Paragnath, ventral and posterior (F).
Fig. 54. First maxilla, posterior (G).
Fig. 55. Second maxilla, posterior (G).
Fig. 56. Maxilliped, posterior and slightly outer (G).



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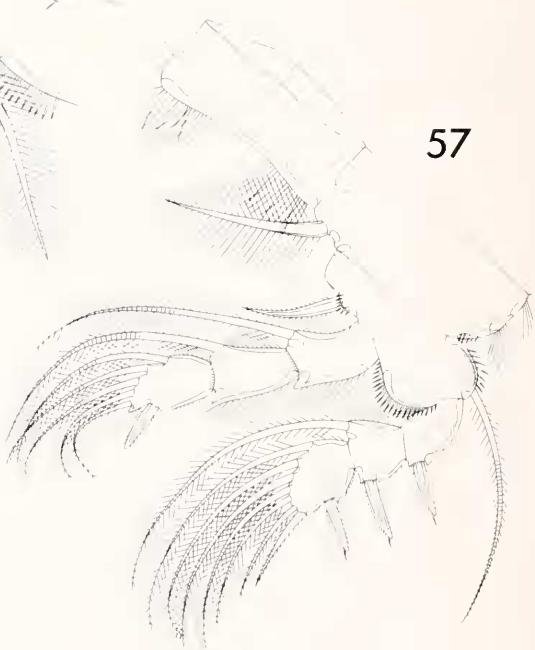

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Plate IX

Hemicyclops amplicaudatus n. sp., female (cantinued)

Fig. 57. Leg 1, anterior (G).
Fig. 58. Leg 2, anterior (G).
Fig. 59. Leg 3, posterior (G).
Fig. 60. Leg 4, posterior (G).

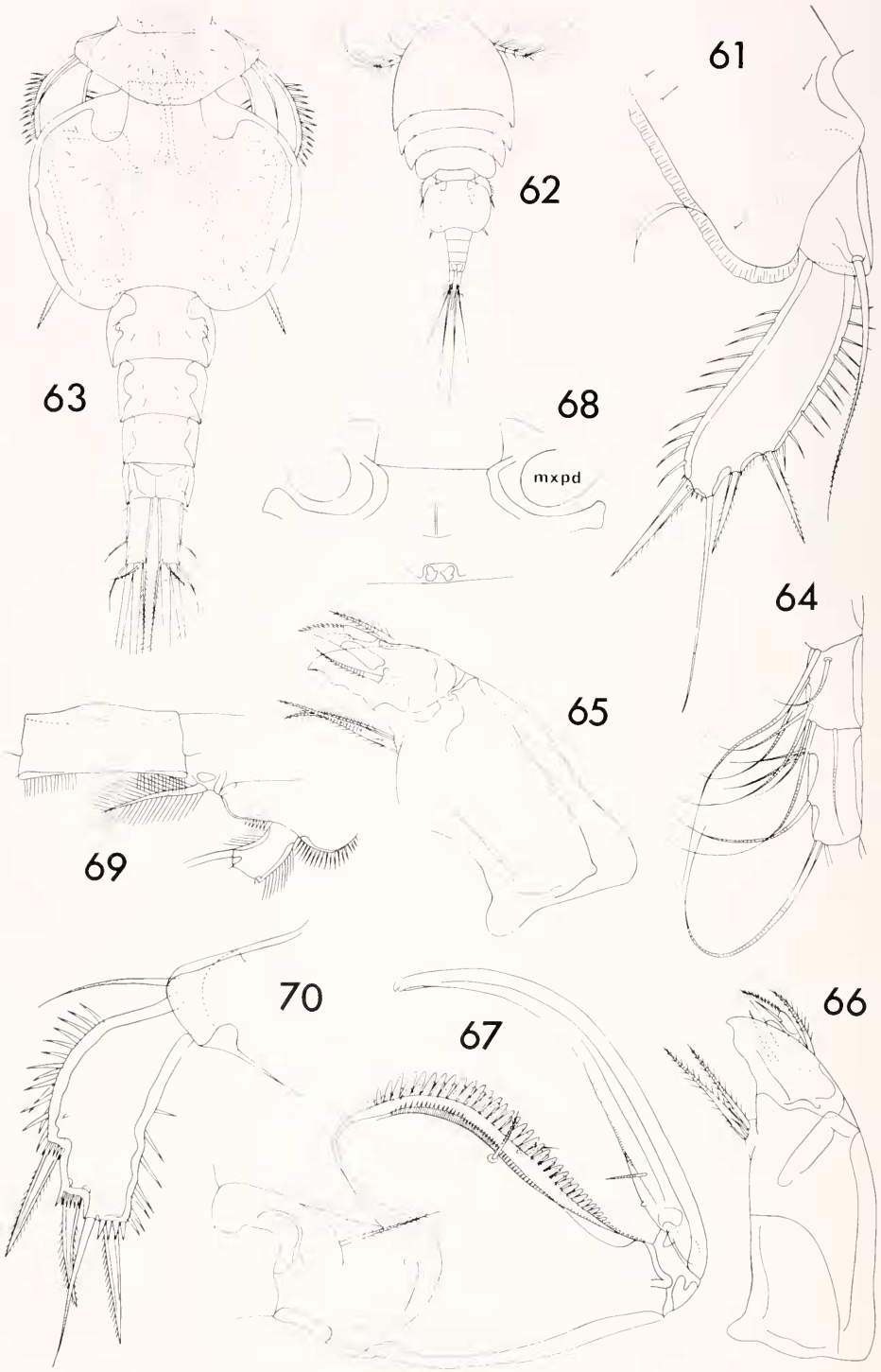
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Plate X

Hemicyclops amplicaudatus n. sp., female (continued)

Fig. 61. Leg 5, dorsal (D).

Hemicyclops amplicaudatus n. sp., male

Fig. 62. Body, dorsal (A).
Fig. 63. Urosome, dorsal (H).
Fig. 64. Segments 3 and 4 of first antenna, ventral (D).
Fig. 65. Second maxilla, anterior (D).
Fig. 66. Second maxilla, posterior (D).
Fig. 67. Maxilliped, anterior (D).
Fig. 68. Area between maxillipeds and leg 1, ventral (H).
Fig. 69. Portion of leg 1, anterior (G).
Fig. 70. Leg 5, ventral (D).

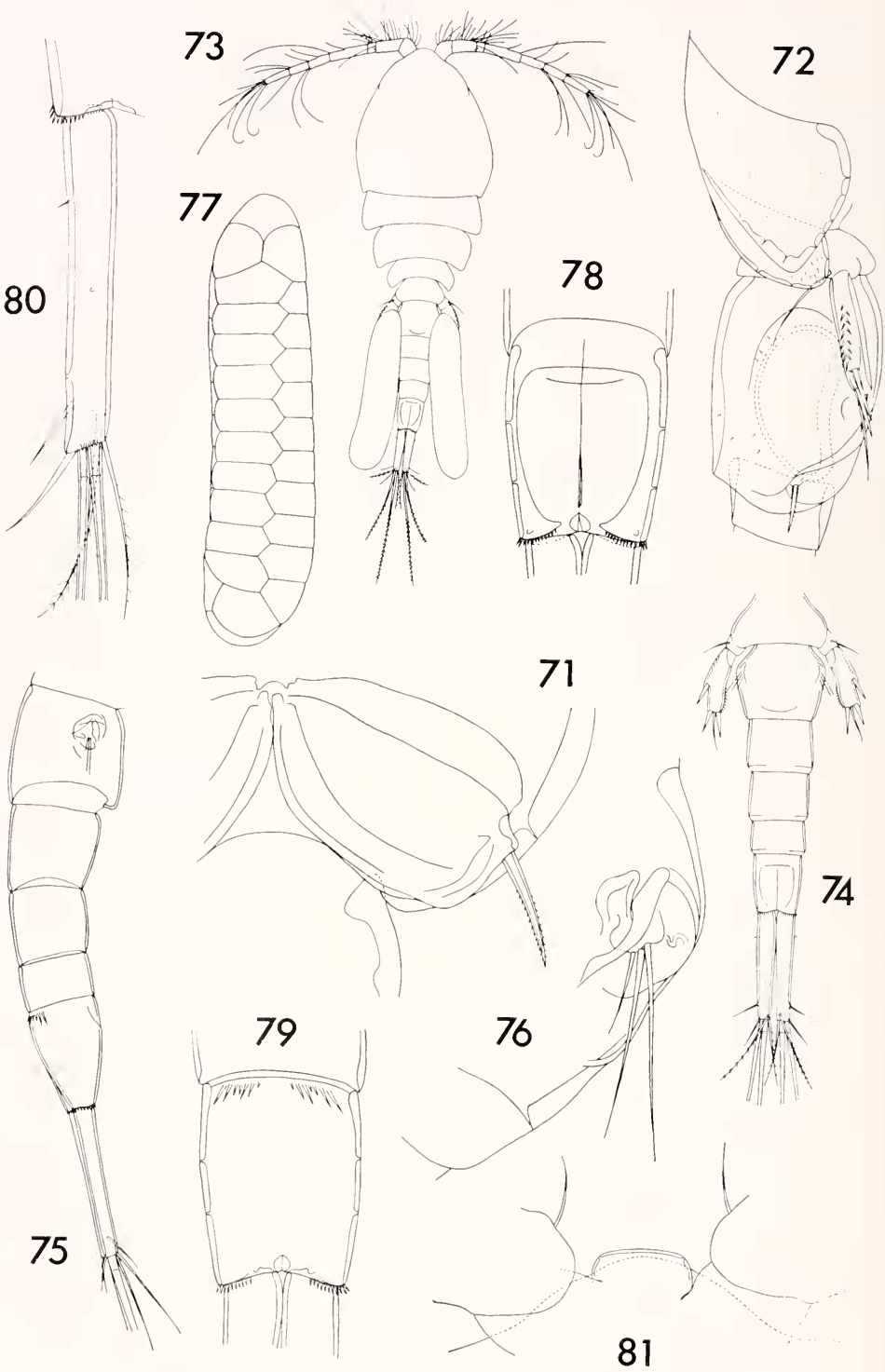
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Plate XI

Hemicyclops amplicaudatus n. sp., male (continued)

Fig. 71. Leg 6, ventral (D).
Fig. 72. Segment of leg 5, genital segment, and adjacent areas, lateral (H).

Hemicyclops carinifer n. sp., female

Fig. 73. Body, dorsal (A).
Fig. 74. Urosome, dorsal (C).
Fig. 75. Urosome, lateral (B).
Fig. 76. Area of attachment of egg sac, dorsal and slightly lateral (E).
Fig. 77. Egg sac, dorsal (B).
Fig. 78. Anal segment, dorsal (G).
Fig. 79. Anal segment, ventral (G).
Fig. 80. Caudal ramus, ventral (G).
Fig. 81. Rostral area, ventral (D).

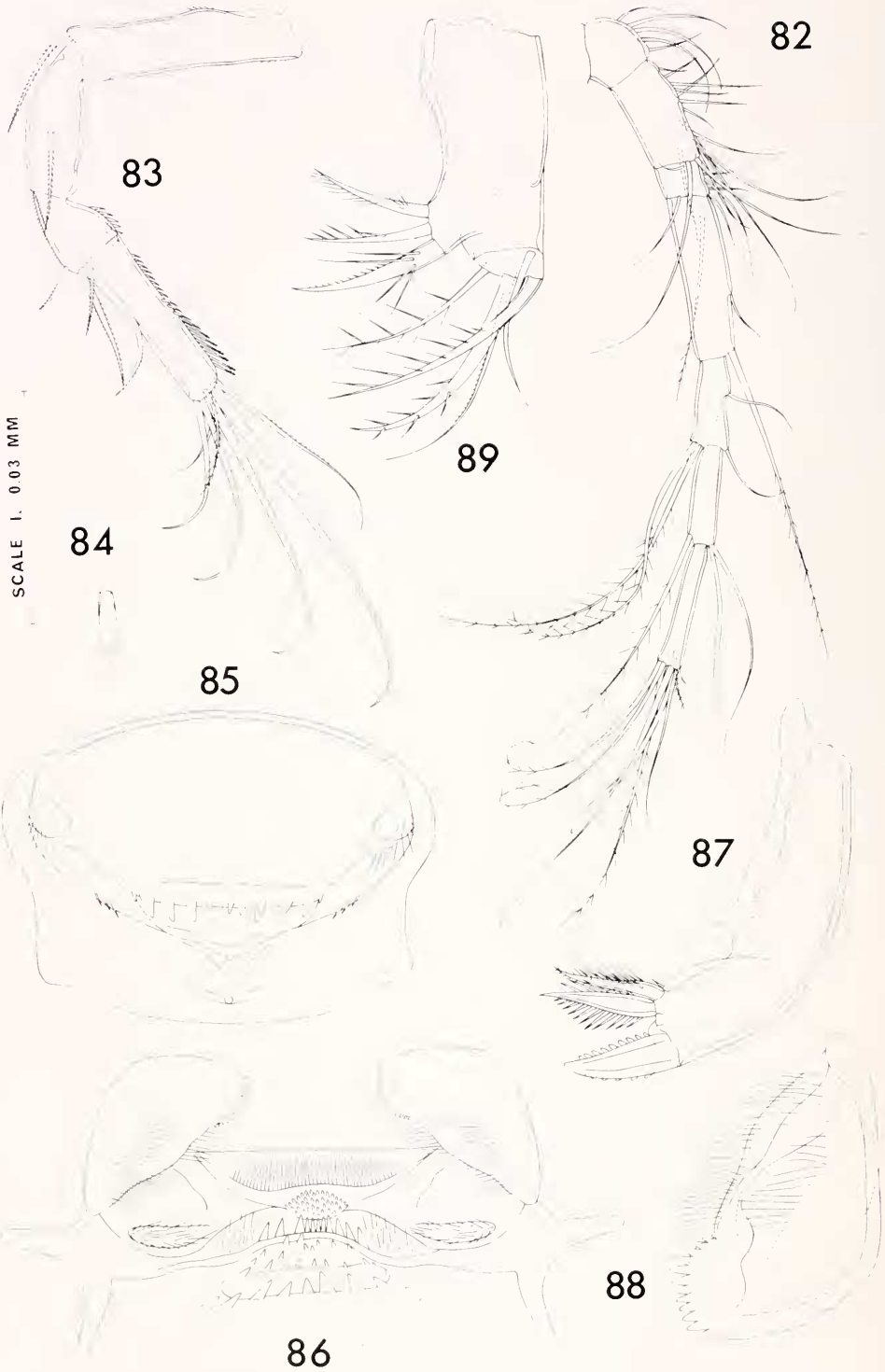
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Plate XII

Hemicyclaps carinifer n. sp., female (cantinued)

Fig. 82. First antenna, dorsal (H).
Fig. 83. Second antenna, posterior mesial (G).
Fig. 84. Seta on third segment of second antenna (I).
Fig. 85. Labrum, anterior and ventral (E).
Fig. 86. Metastomal areas and paragnaths, ventral (E).
Fig. 87. Mandible, posterior (E).
Fig. 88. Paragnath, ventral and posterior (F).
Fig. 89. First maxilla, posterior (E).

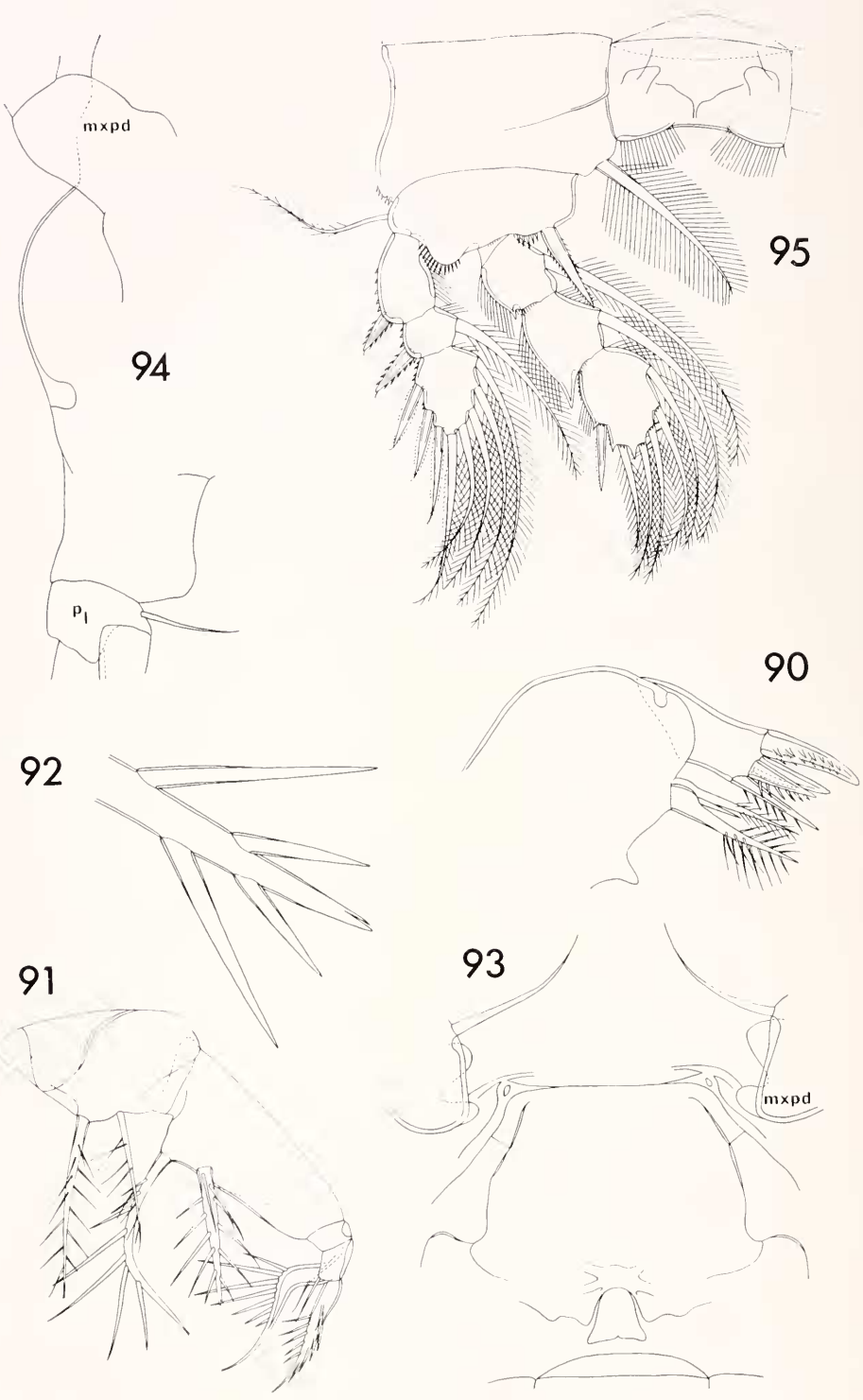
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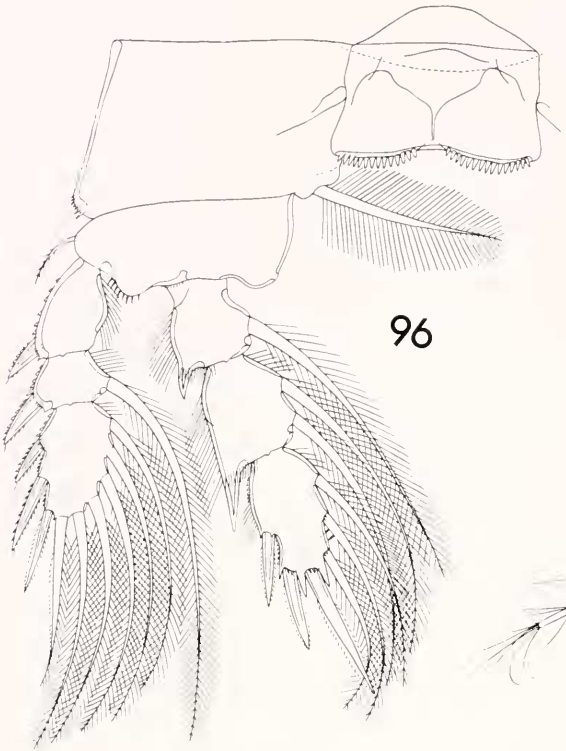
Plate XIII

Hemicyclops carinifer n. sp., female (continued)

Fig. 90. Second maxilla, posterior and dorsal (D).
Fig. 91. Maxilliped, dorsal (G).
Fig. 92. Terminal part of distal seta on second segment of maxilliped (I).
Fig. 93. Area between maxillipeds and leg 1, ventral (G).
Fig. 94. Area between maxillipeds and leg 1, lateral (G).
Fig. 95. Leg 1, anterior (G).



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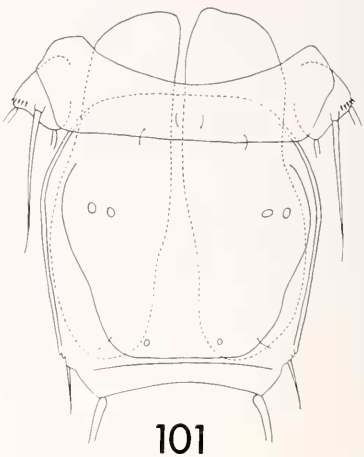

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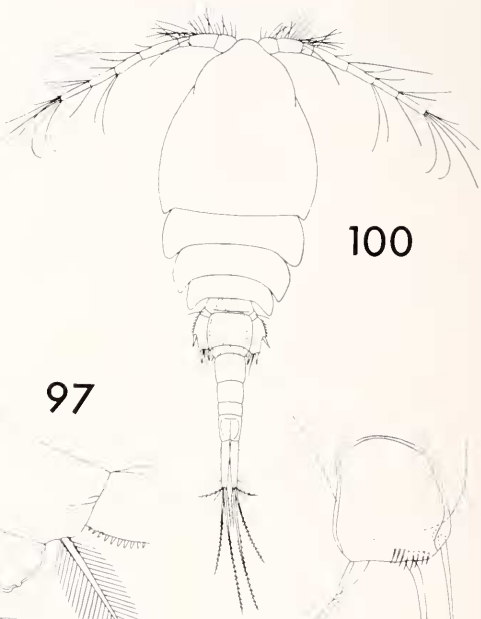

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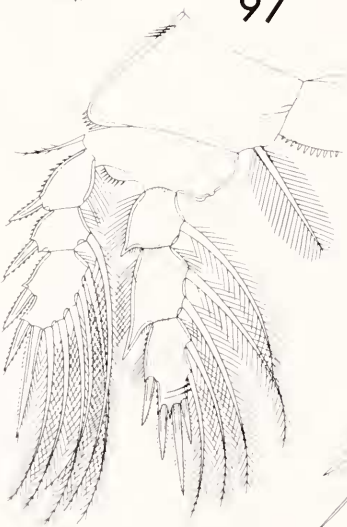

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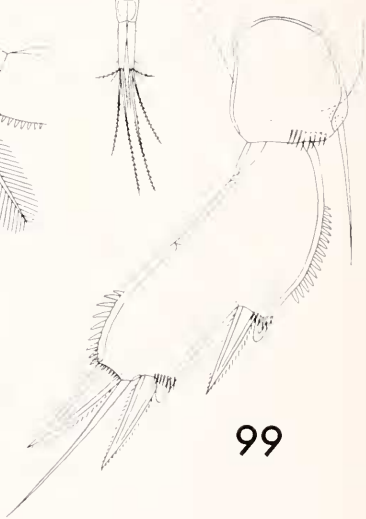

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Plate XIV

Hemicyclops carinifer n. sp., female (cantinued)

Fig. 96. Leg 2, anterior (G).
Fig. 97. Leg 3, posterior (H).
Fig. 98. Leg 4, posterior (H).
Fig. 99. Leg 5, ventral and lateral (D).

Hemicyclops carinifer n. sp., male

Fig. 100. Body, dorsal (A).
Fig. 101. Segment of leg 5 and genital segment, dorsal (G).

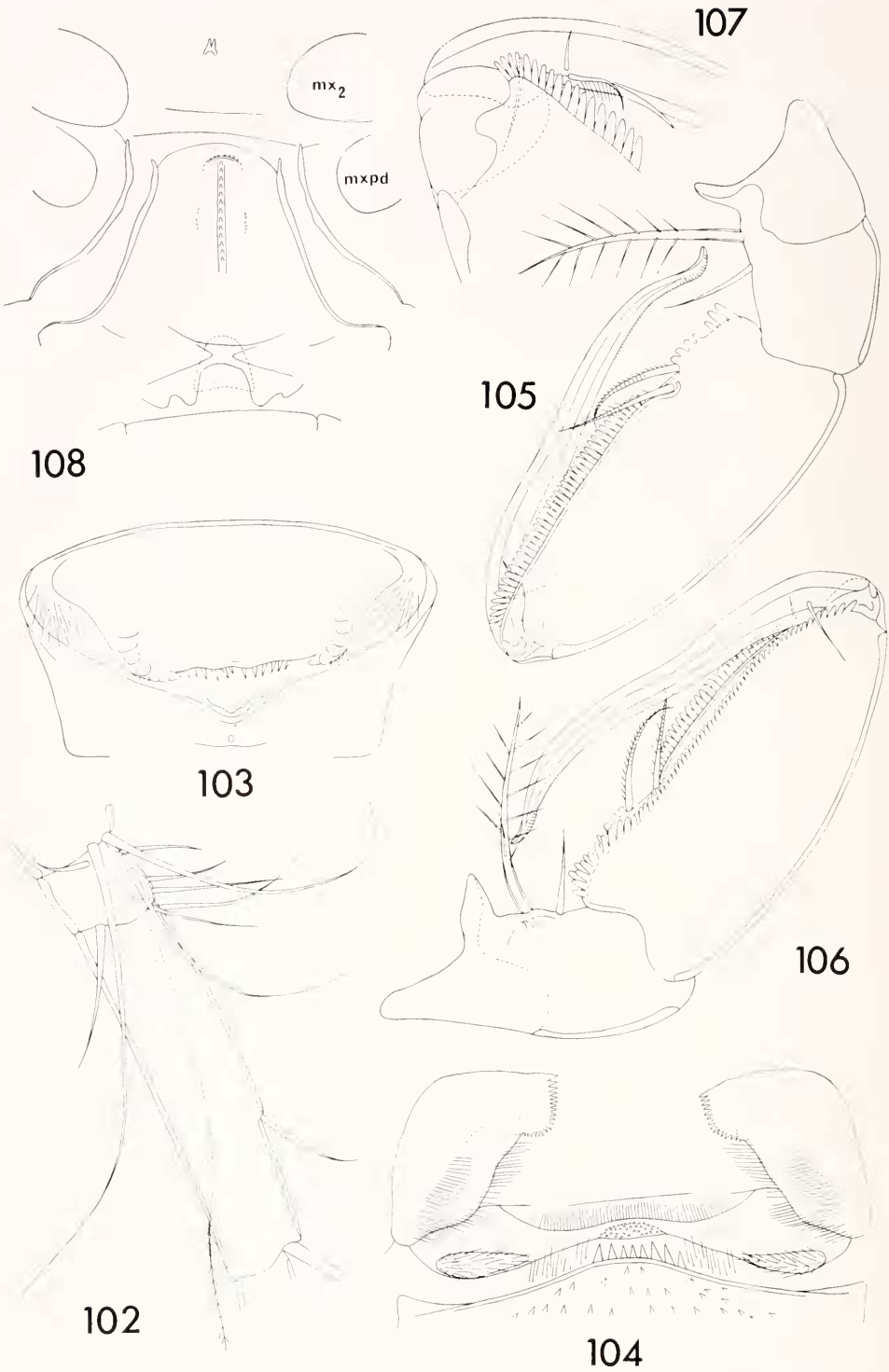
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Plate XV

Hemicyclops carinifer n. sp., male (continued)

Fig. 102. Third and fourth segments of first antenna, dorsal (D).
Fig. 103. Labrum, ventral and anterior (E).
Fig. 104. Metastomal areas and paragnaths, ventral (E).
Fig. 105. Maxilliped, anterior (G).
Fig. 106. Maxilliped, posterior (G).
Fig. 107. Detail of third and fourth segments of maxilliped, anterior (E).
Fig. 108. Area between maxillipeds and leg 1, ventral (G).

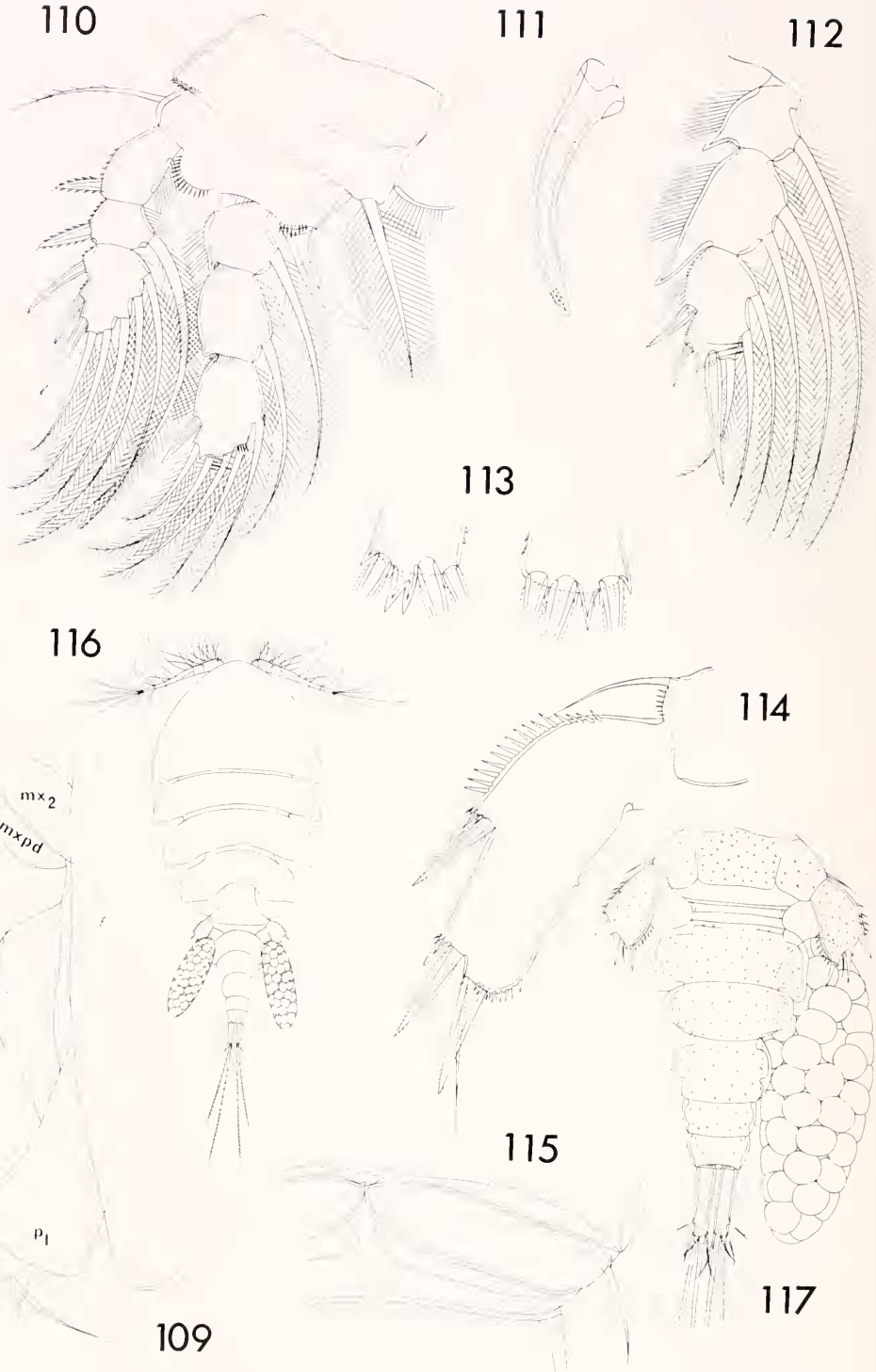
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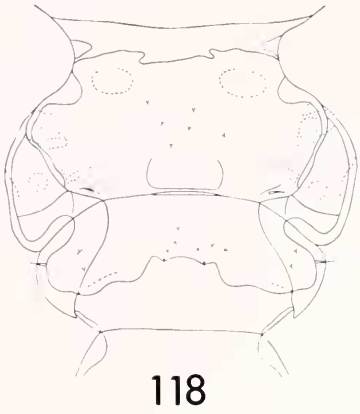
Plate XVI

Hemicyclops carinifer n. sp., male (continued)

Fig. 109. Area between maxillipeds and leg 1, lateral (G).
Fig. 110. Leg 1, anterior (G).
Fig. 111. Inner spine on basis of leg 1, posterior (E).
Fig. 112. Endopod of leg 2, posterior (G).
Fig. 113. Distal margins of endopods in leg 3 of 1 male, posterior (E).
Fig. 114. Leg 5, dorsomesial (D).
Fig. 115. Leg 6, ventral (E).

Hemicyclops diremptus n. sp., female

Fig. 116. Body, dorsal (A).
Fig. 117. Urosome, ventral (C).



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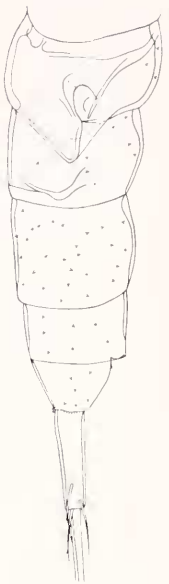

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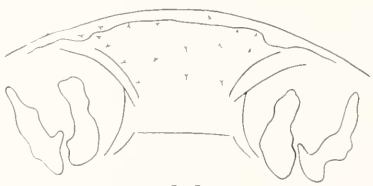

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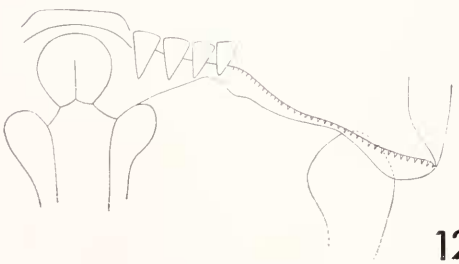

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Plate XVII

Hemicyclaps diremptus n. sp., female (continued)

Fig. 118. Genital segment, dorsal (H).
Fig. 119. Genital and postgenital segments, lateral (B).
Fig. 120. Area of insertion of a caudal ramus, ventral (I)
Fig. 121. Caudal ramus, dorsal (D).
Fig. 122. Rostral area, ventral (G).
Fig. 123. First antenna, ventral (G).

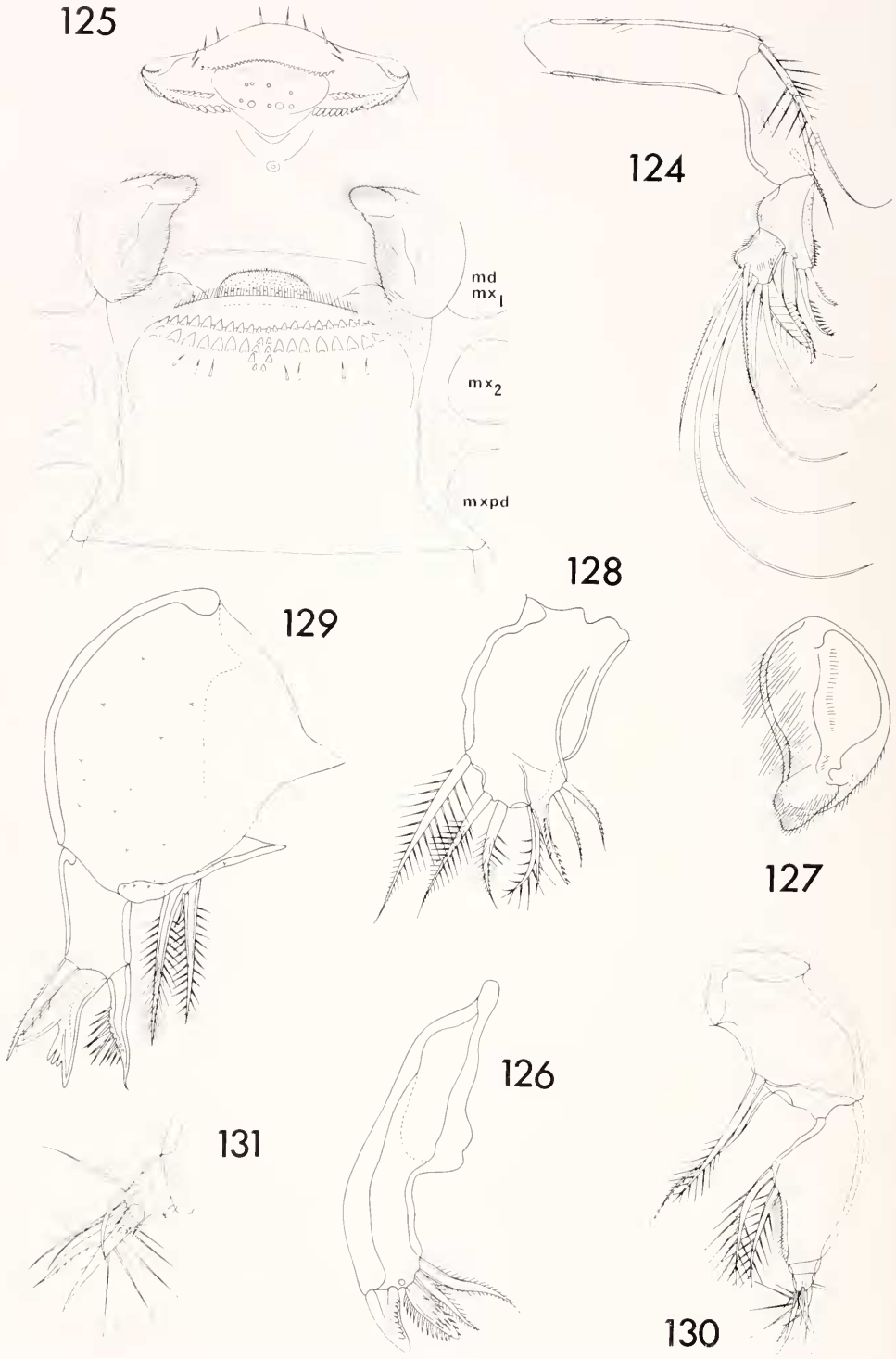
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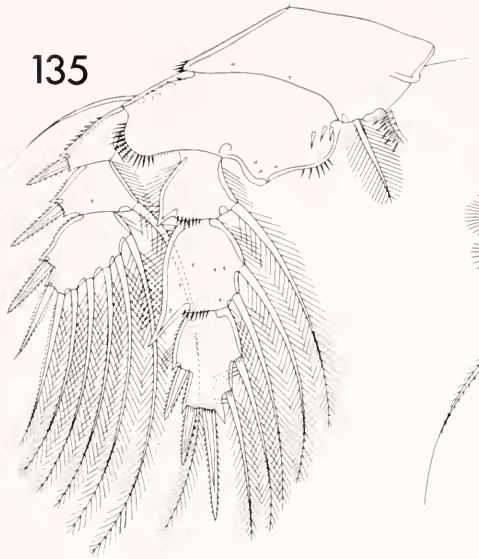
Plate XVIII

Hemicyclops diremptus n. sp., female (continued)

Fig. 124. Second antenna, anterior (G).
Fig. 125. Oral area, ventral (D).
Fig. 126. Mandible, posterior and ventral (D).
Fig. 127. Paragnath, posterodorsal (E).
Fig. 128. First maxilla, posterior (D).
Fig. 129. Second maxilla, anterior (D).
Fig. 130. Maxilliped, anterodorsal (G).
Fig. 131. Tip of maxilliped, posteroventral (E).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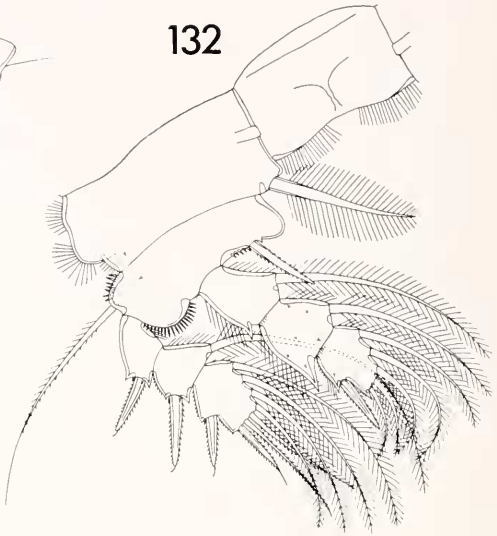
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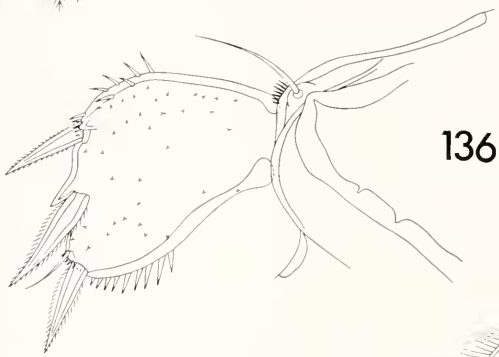
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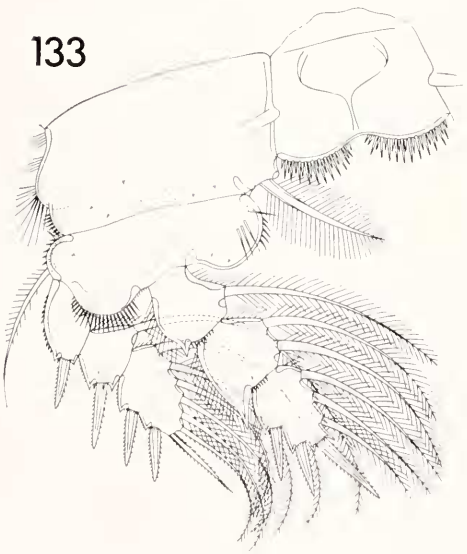
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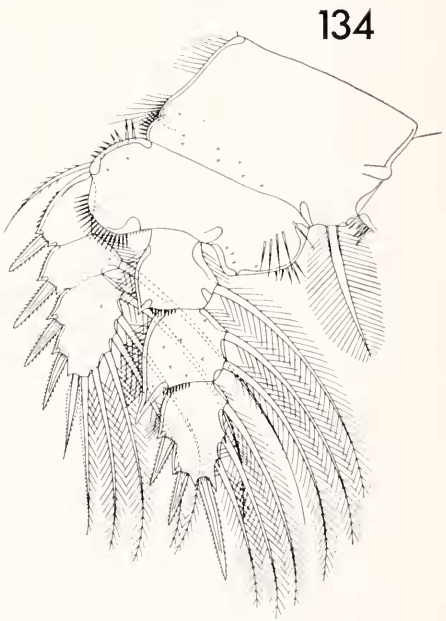
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Plate XIX

Hemicyclaps diremptus n. sp., female (cantinued)

Fig. 132. Leg 1, anteriar (H).
Fig. 133. Leg 2, anteriar (H).
Fig. 134. Leg 3, anteriar (H).
Fig. 135. Leg 4, anteriar (H).
Fig. 136. Leg 5, dorsal (G).

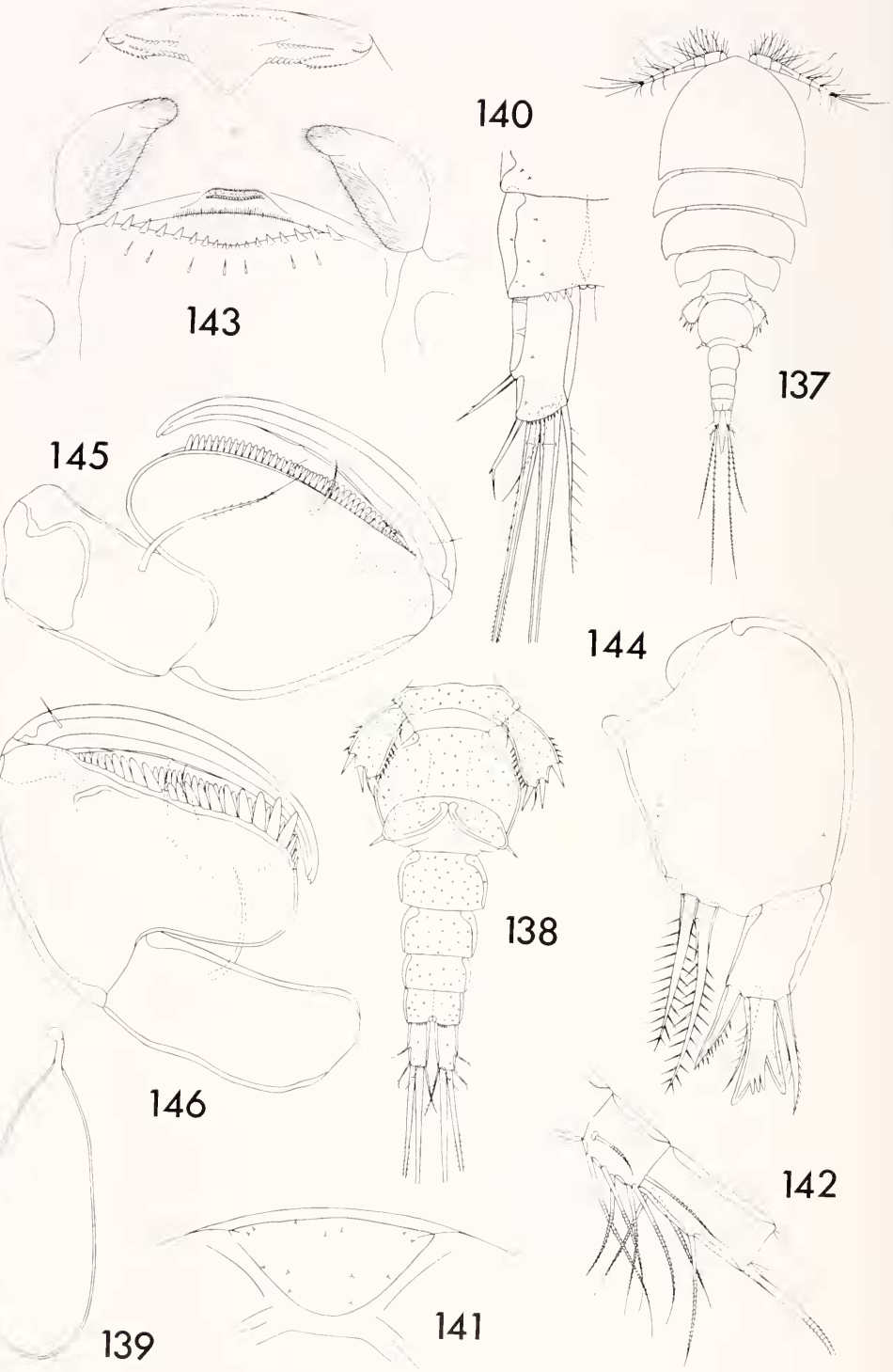
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Plate XX

Hemicyclops diremptus n. sp., male

Fig. 137. Body, dorsal (A).
Fig. 138. Urosome, ventral (C).
Fig. 139. Spermataphore from inside body of male (E).
Fig. 140. Caudal ramus and part of anal segment, ventral (D).
Fig. 141. Rostral area, ventral (E).
Fig. 142. Third and fourth segments of first antenna, ventral (D).
Fig. 143. Oral area, ventral (E).
Fig. 144. Second maxilla, anterior (E).
Fig. 145. Maxilliped, anterior (D).
Fig. 146. Maxilliped, posterior (D).

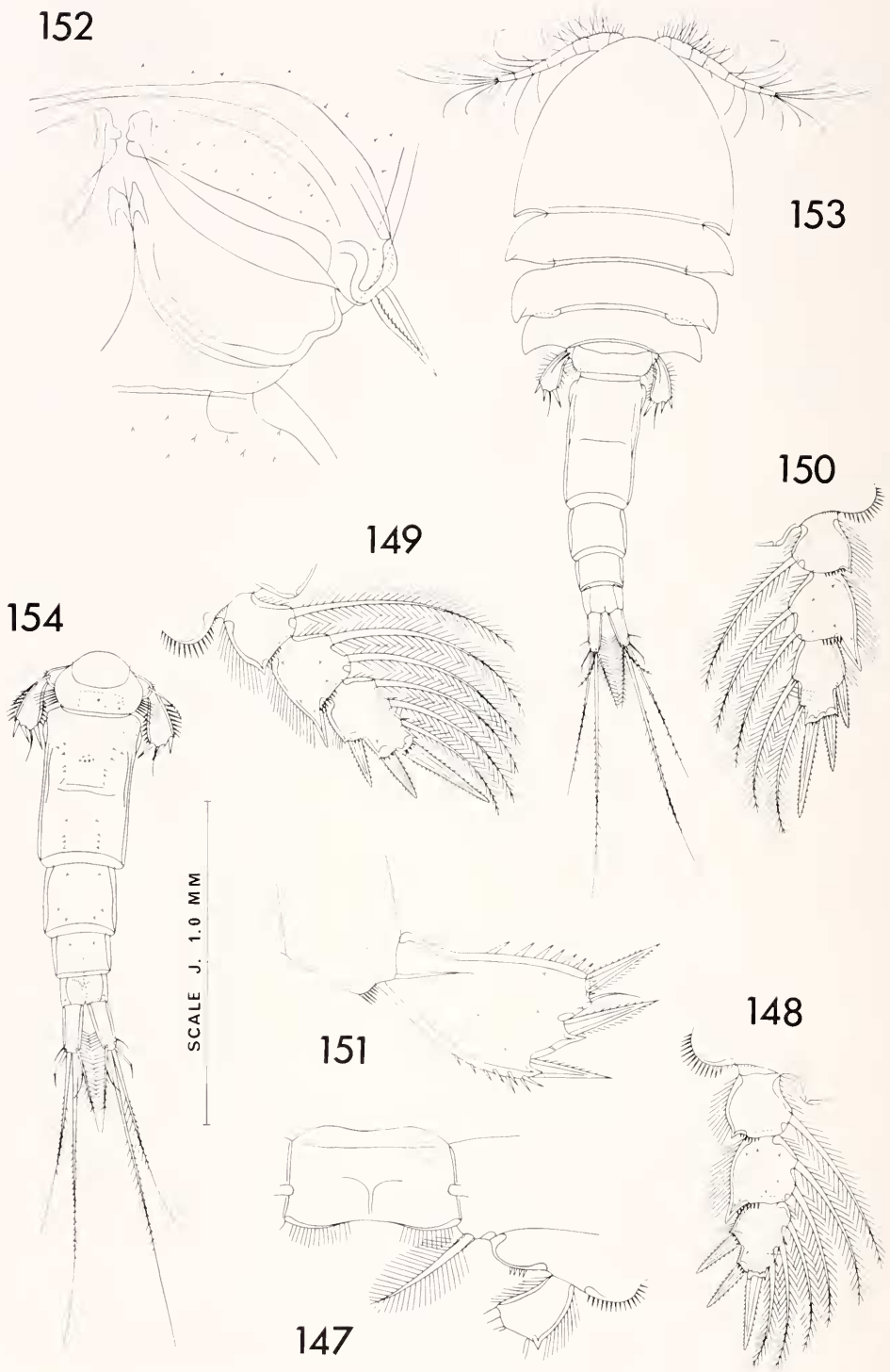
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Plate XXI

Hemicyclops diremptus n. sp., male (continued)

Fig. 147. Portion of leg 1, anterior (G).
Fig. 148. Endopod of leg 2, anterior (G).
Fig. 149. Endopod of leg 3, anterior (G).
Fig. 150. Endopod of leg 4, anterior (G).
Fig. 151. Leg 5, dorsal (D).
Fig. 152. Leg 6, ventral (E).

Hemicyclops kombensis n. sp., female

Fig. 153. Body, dorsal (A).
Fig. 154. Urosome, dorsal (J).

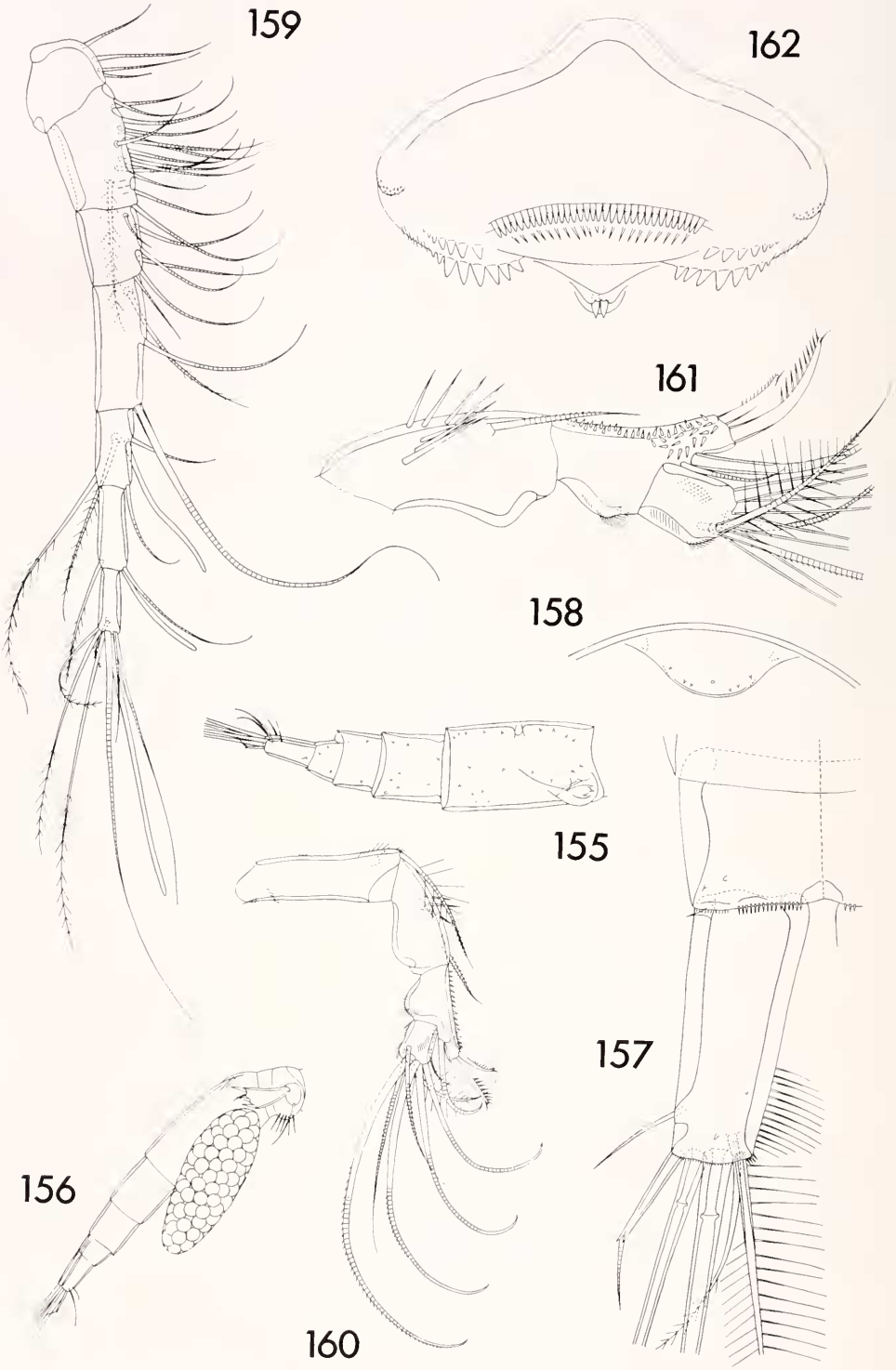
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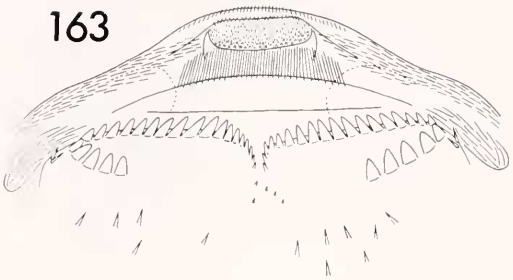
Plate XXII

Hemicyclops kambensis n. sp., female (cantinued)

Fig. 155. Genital and pastgenital segments, nearly lateral (J).
Fig. 156. Egg sac attached ta urasame, nearly lateral (A).
Fig. 157. Caudal ramus, ventral (G).
Fig. 158. Rastral area, ventral (G).
Fig. 159. First antenna, ventral (H).
Fig. 160. Secand antenna, anteriar (H).
Fig. 161. Last three segments af second antenna, pasteriar (D).
Fig. 162. Labrum, ventral and samewhat posteriar (E).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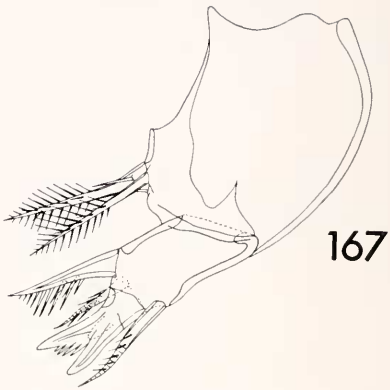
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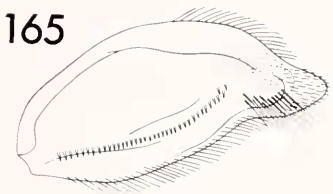
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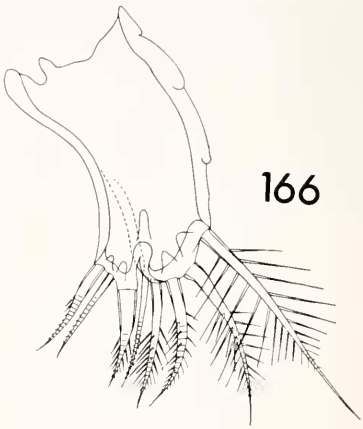
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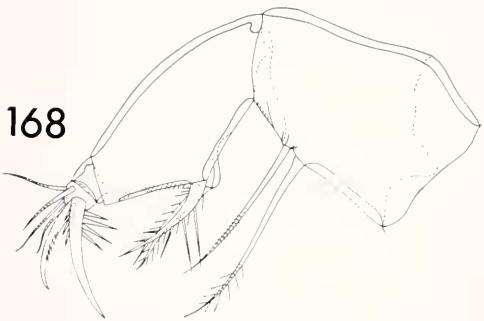
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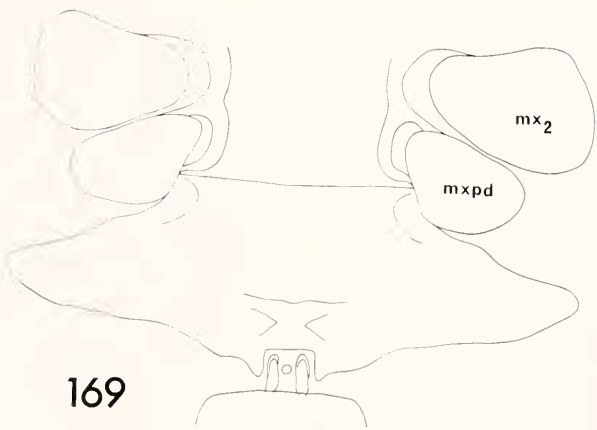
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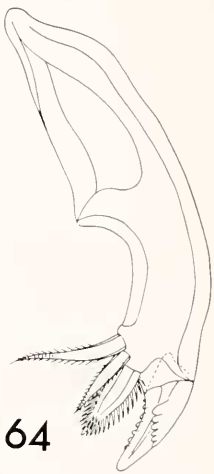
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Plate XXIII

Hemicyclops kombensis n. sp., female (continued)

Fig. 163. Metastomal areas, ventral (E).
Fig. 164. Mandible, anterior and dorsal (D).
Fig. 165. Paragnath, posterior and ventral (E).
Fig. 166. First maxilla, posterior (D).
Fig. 167. Second maxilla, anterior (G).
Fig. 168. Maxilliped, posterior and ventral (G).
Fig. 169. Region between maxillipeds and leg 1, ventral (H).

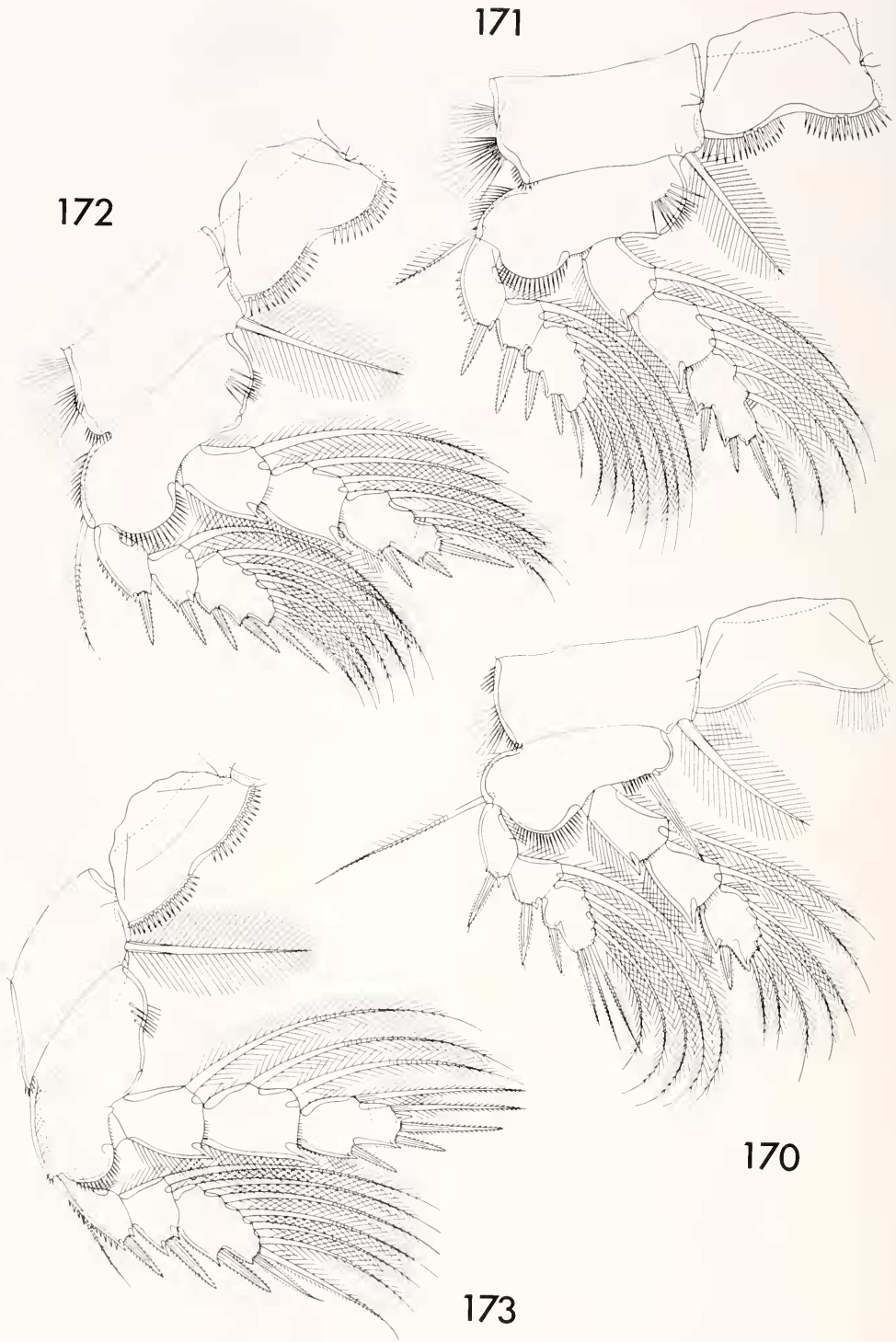
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Plate XXIV

Hemicyclops kombensis n. sp., female (continued)

Fig. 170. Leg 1, anterior (H).
Fig. 171. Leg 2, anterior (H).
Fig. 172. Leg 3, anterior (H).
Fig. 173. Leg 4, anterior (H).

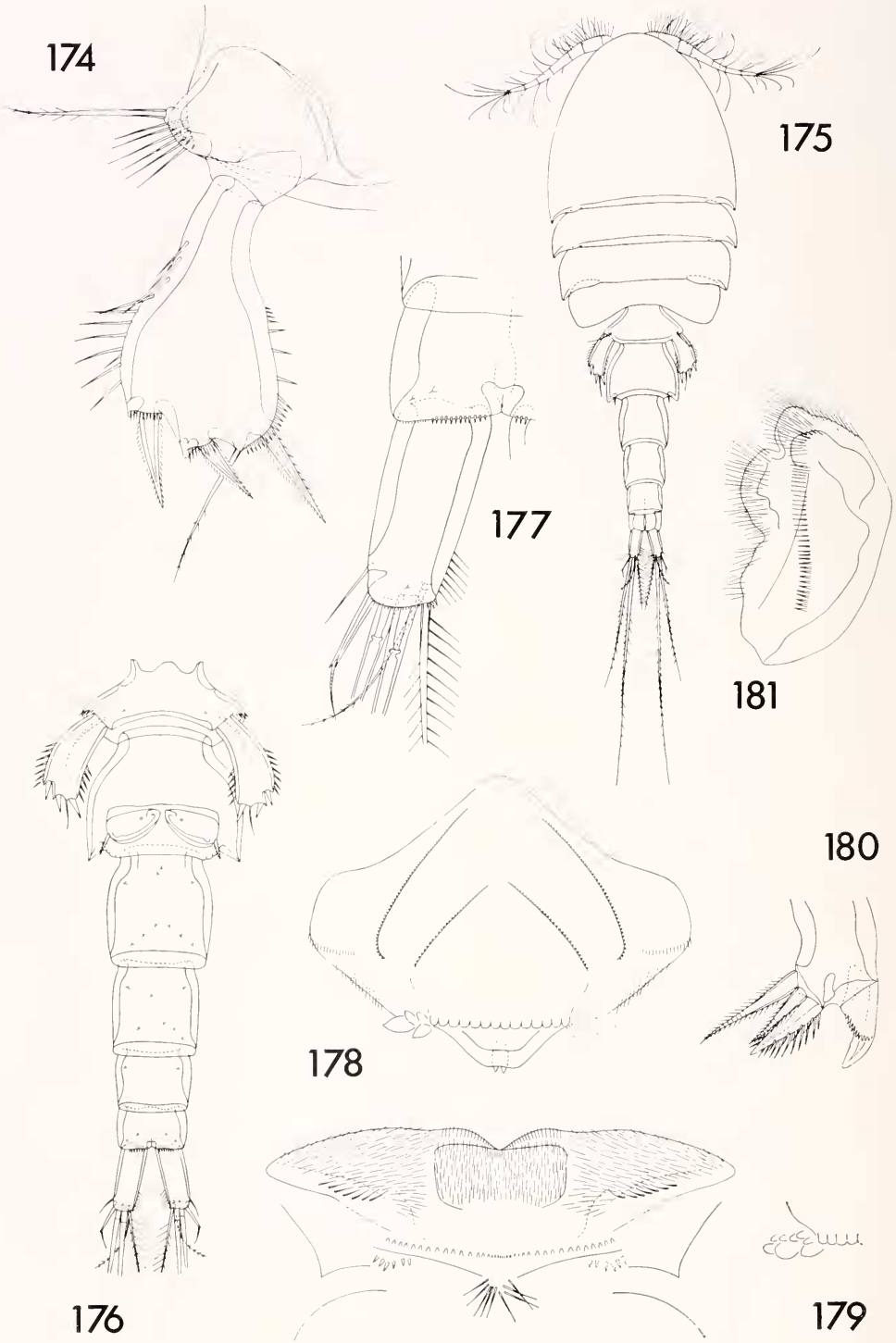
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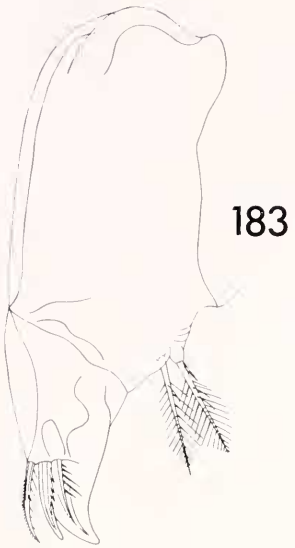
Plate XXV

Hemicyclops kambensis n. sp., female (continued)

Fig. 174. Leg 5, ventral (G).

Hemicyclops kambensis n. sp., male

Fig. 175. Body, dorsal (A).
Fig. 176. Urosome, ventral (C).
Fig. 177. Caudal ramus and part of anal segment, ventral (G).
Fig. 178. Labrum and metastomal areas, ventral (E).
Fig. 179. Spines at corner of labrum, ventral (E).
Fig. 180. Tip of mandible, anterior (D).
Fig. 181. Paragnath, posterior and ventral (E).



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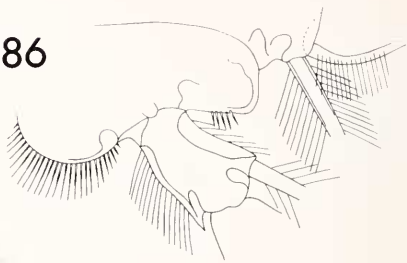

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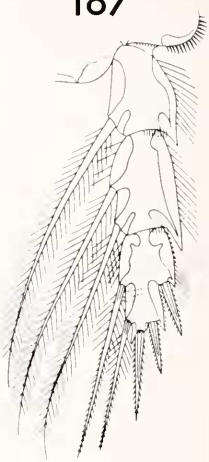

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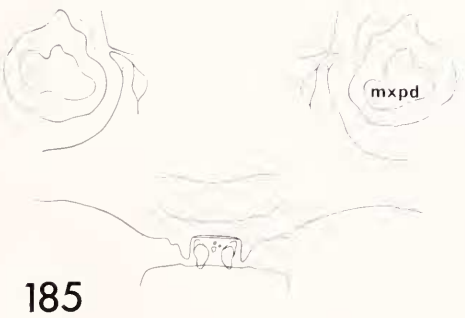

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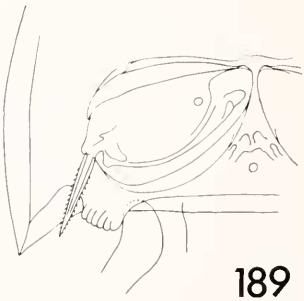

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Plate XXVI

Hemicyclops kambensis n. sp., male (continued)

Fig. 182. First maxilla, posterior (D).
Fig. 183. Second maxilla, anterior (G).
Fig. 184. Maxilliped, anterior (H).
Fig. 185. Region between maxillipeds and leg 1, ventral (H).
Fig. 186. Detail of leg 1, anterior (G).
Fig. 187. Endopod of leg 4, anterior (H).
Fig. 188. Leg 5, dorsal (G).
Fig. 189. Leg 6, ventral (G).

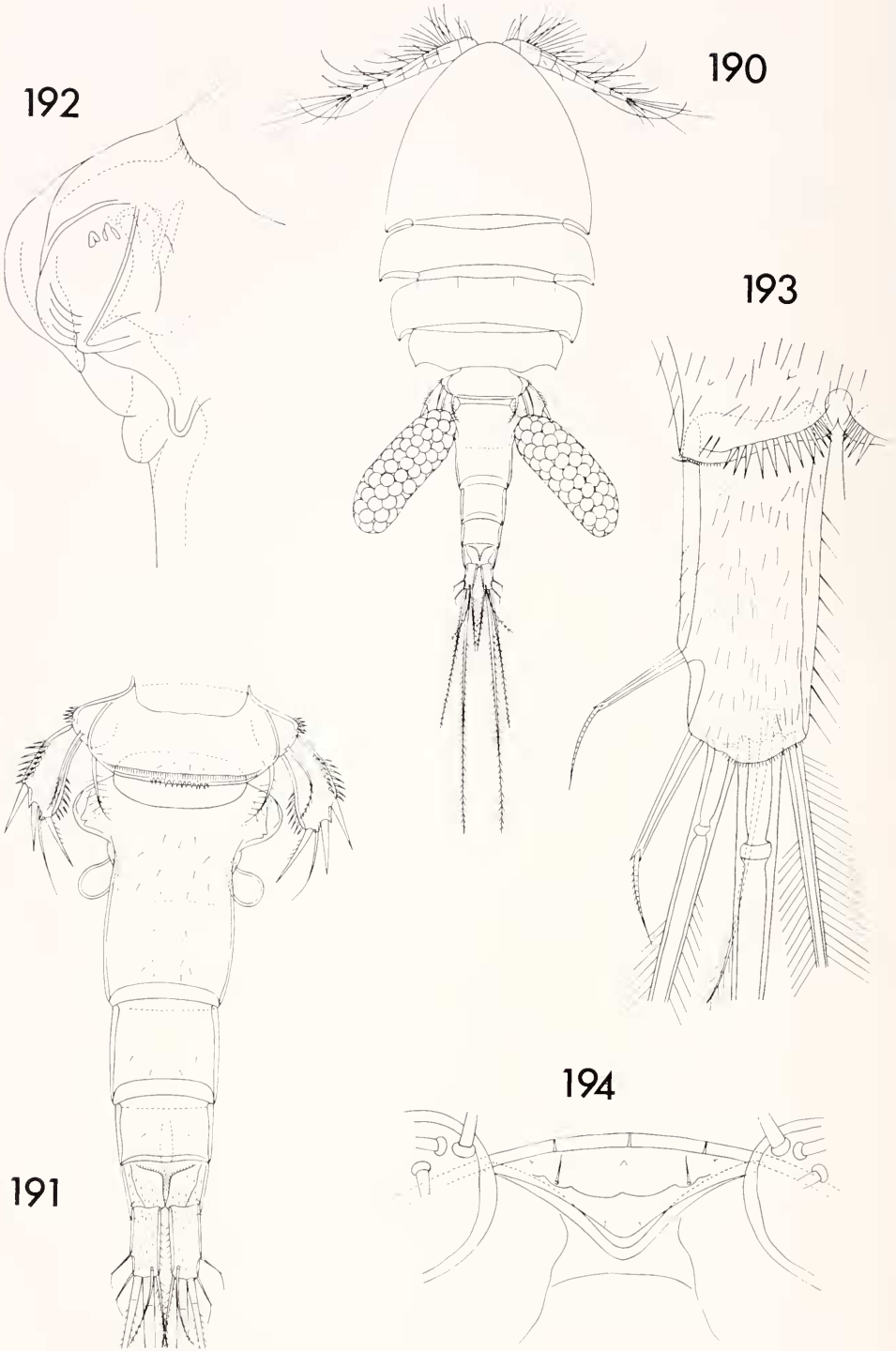
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Plate XXVII

Hemicyclops biflagellatus n. sp., female

Fig. 190. Body, dorsal (J).
Fig. 191. Urosome, dorsal (B).
Fig. 192. Area of attachment of egg sac, dorsal (E).
Fig. 193. Caudal ramus, ventral (E).
Fig. 194. Rostral area, ventral (E).

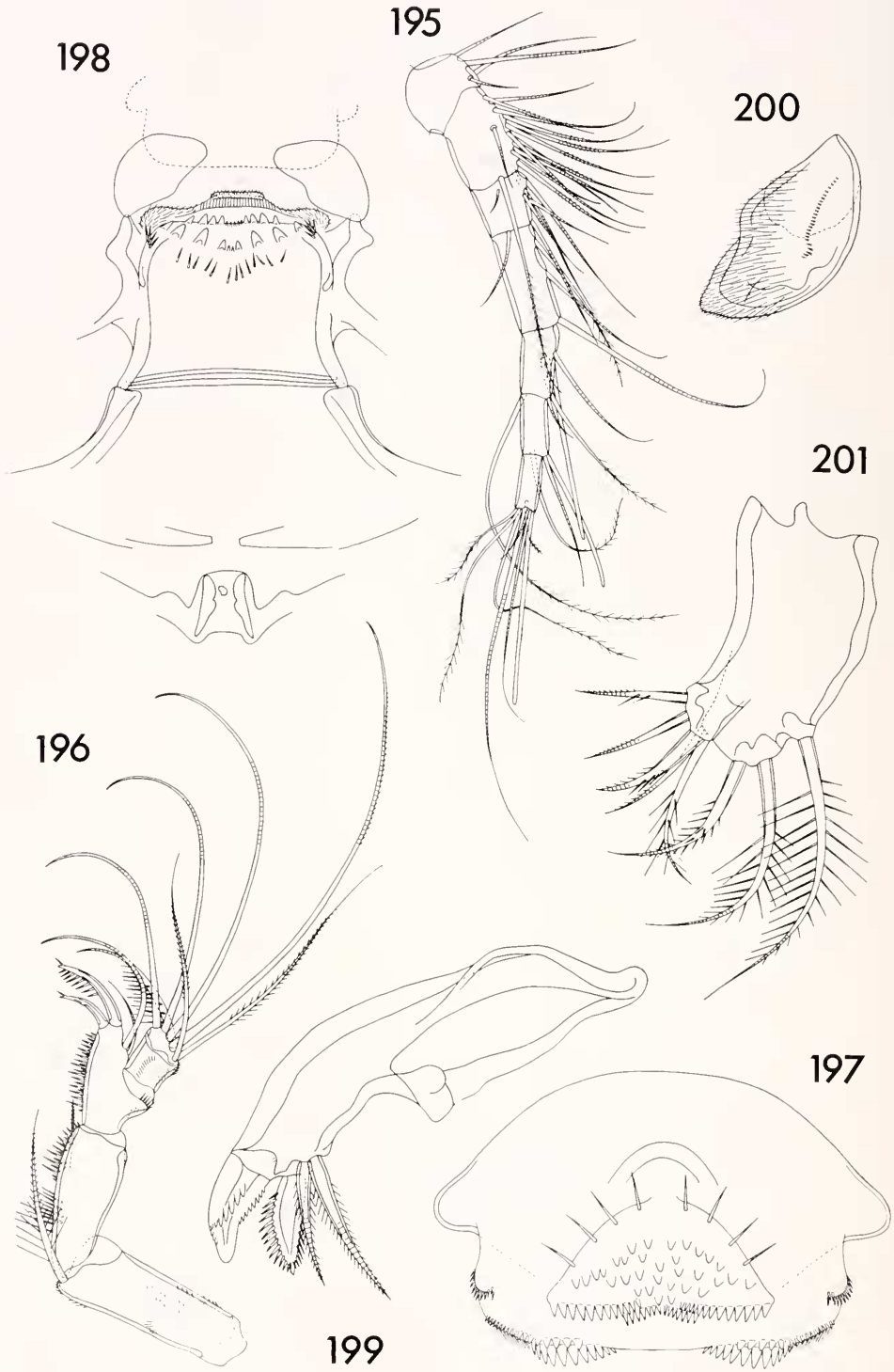
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Plate XXVIII

Hemicyclops biflagellatus n. sp., female (continued)

Fig. 195. First antenna, anteradorsal (H).
Fig. 196. Secand antenna, anteriar (G).
Fig. 197. Labrum, ventral (E).
Fig. 198. Metastamal areas and regian between maxillipeds and leg 1 (with outline af labrum in dashed lines), ventral (G).
Fig. 199. Mandible, anteriar and darsal (E).
Fig. 200. Paragnath, pasteriar (E).
Fig. 201. First maxilla, pasteriar (E).


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Plate XXIX

Hemicyclops biflagellatus n. sp., female (continued)

Fig. 202. Second maxilla, anterior (E).
Fig. 203. Maxilliped, dorsal (D).
Fig. 204. Leg 1, anterior (G).
Fig. 205. Leg 2, anterior (G).

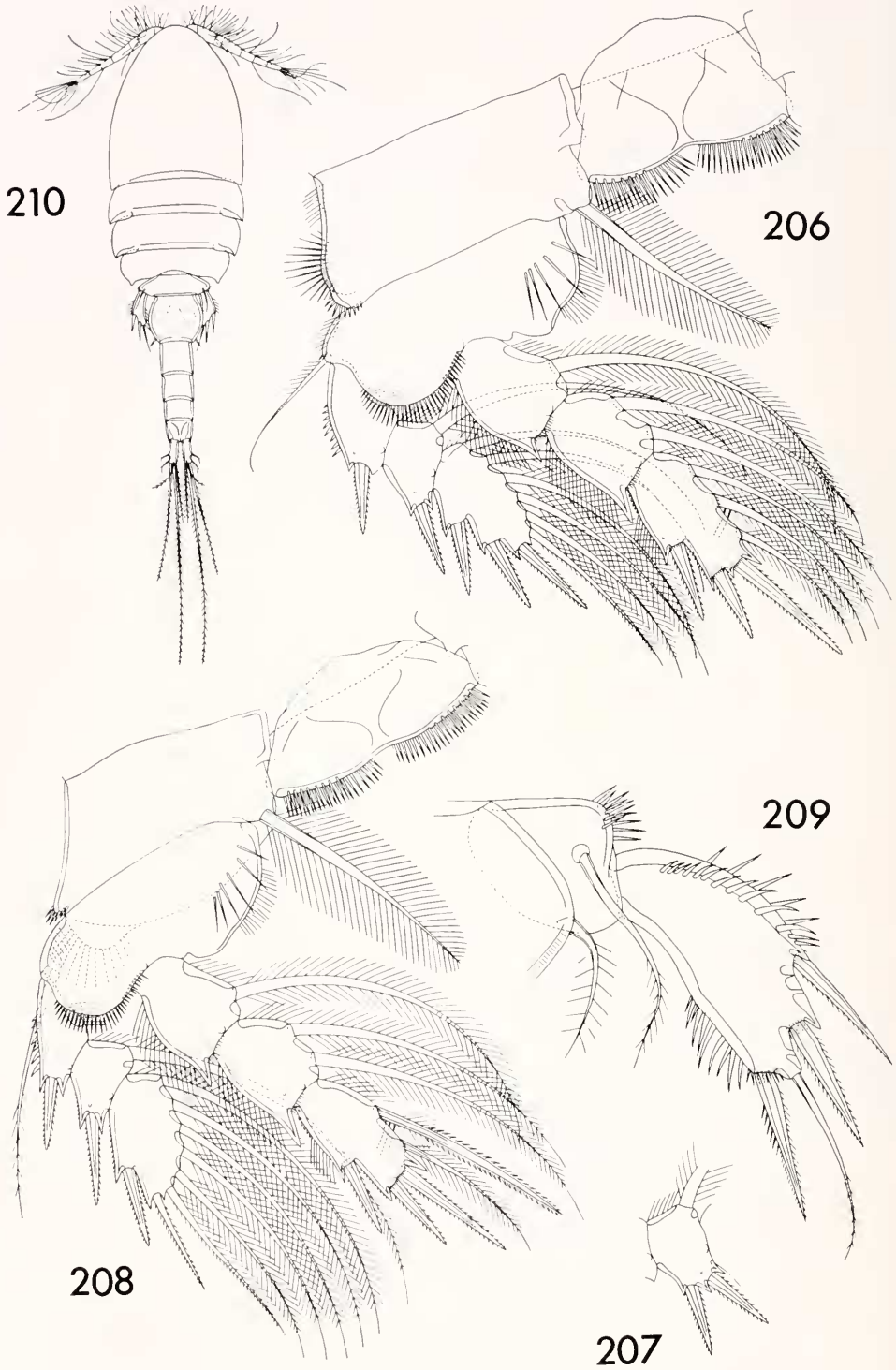
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Plate XXX

Hemicyclops biflagellatus n. sp., female (continued)

Fig. 206. Leg 3, anterior (G).
Fig. 207. Abnormal second segment of exopod of leg 3, anterior (G).
Fig. 208. Leg 4, anterior (G).
Fig. 209. Leg 5, dorsal (D).

Hemicyclops biflagellatus n. sp., male

Fig. 210. Body, dorsal (J).

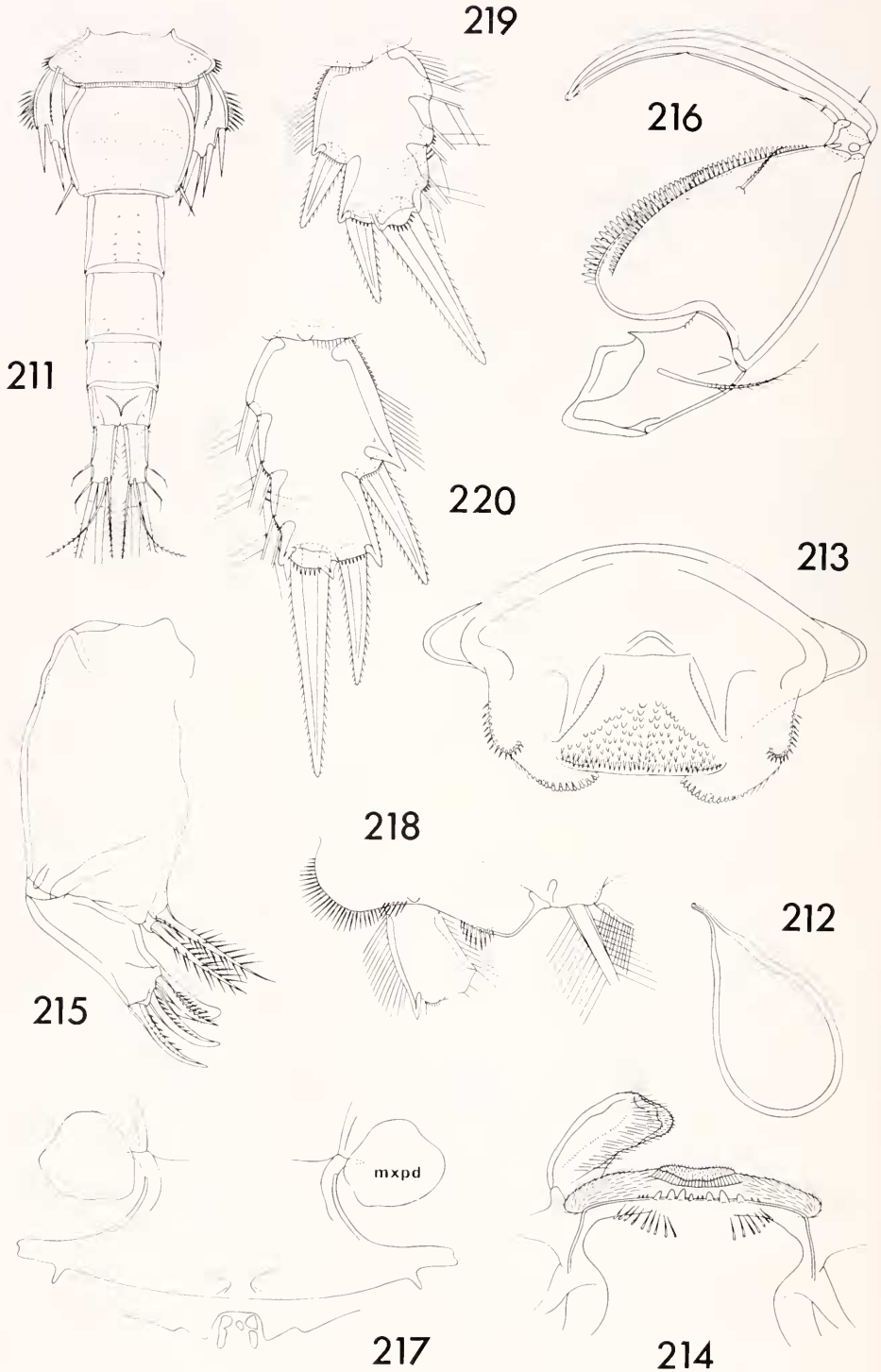
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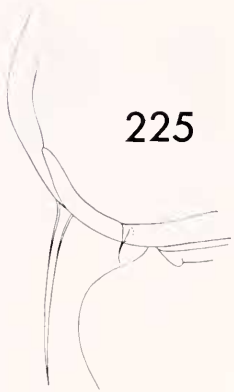
Plate XXXI

Hemicyclops biflagellatus n. sp., male (cantinued)

Fig. 211. Urosome, dorsal (B).
Fig. 212. Spermatophore attached to female, ventral (E).
Fig. 213. Labrum, ventrol (E).
Fig. 214. Metastomal areas, with one paragnath in position, ventrol (D).
Fig. 215. Second maxilla, anterior (D).
Fig. 216. Maxilliped, anterior (G).
Fig. 217. Region between maxillipeds and leg 1, ventral (G).
Fig. 218. Detail of leg 1, anterior (D).
Fig. 219. Lost segment of endopod of leg 2, anterior (E).
Fig. 220. Last segment of endopod of leg 3, anterior (E).



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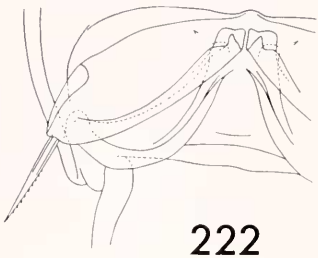

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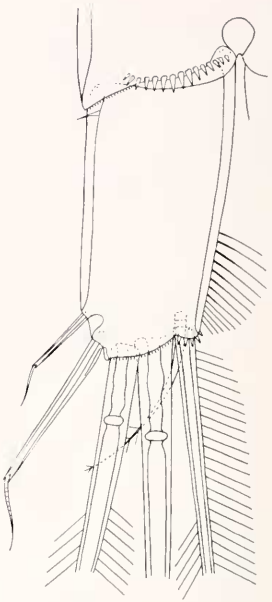

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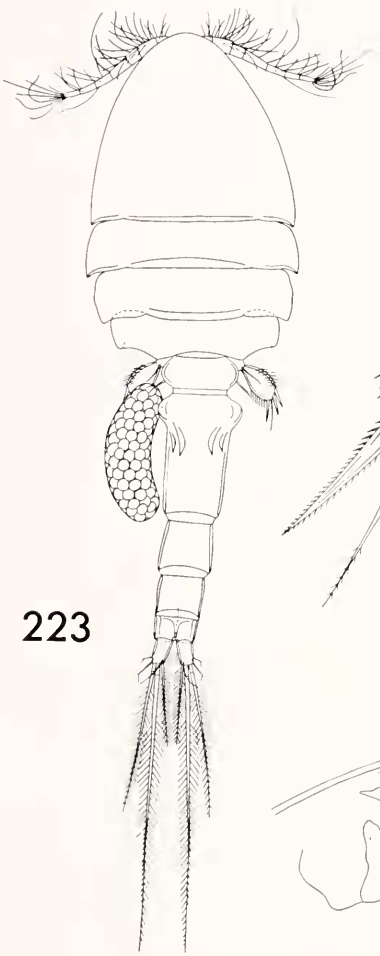

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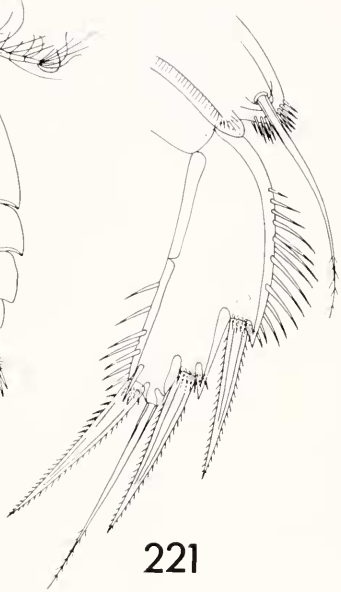

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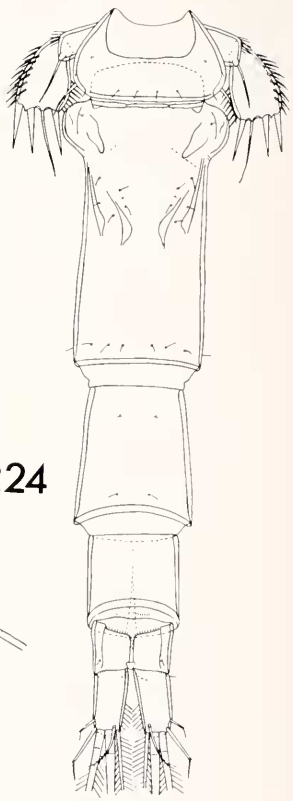

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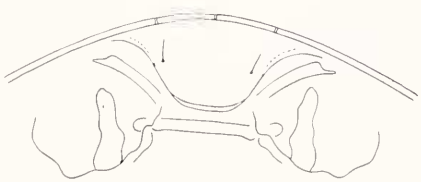

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Plate XXXII

Hemicyclops biflagellatus n. sp., male (continued)

Fig. 221. Leg 5, dorsal (D).
Fig. 222. Leg 6, ventral (D).

Hemicyclops acanthosquillae n. sp., female

Fig. 223. Body, dorsal (A).
Fig. 224. Urosome, dorsal (C).
Fig. 225. Portion of segment of leg 5 showing setiform process, dorsal (D).
Fig. 226. Caudal ramus, ventral (D).
Fig. 227. Rostral area, ventral (G).

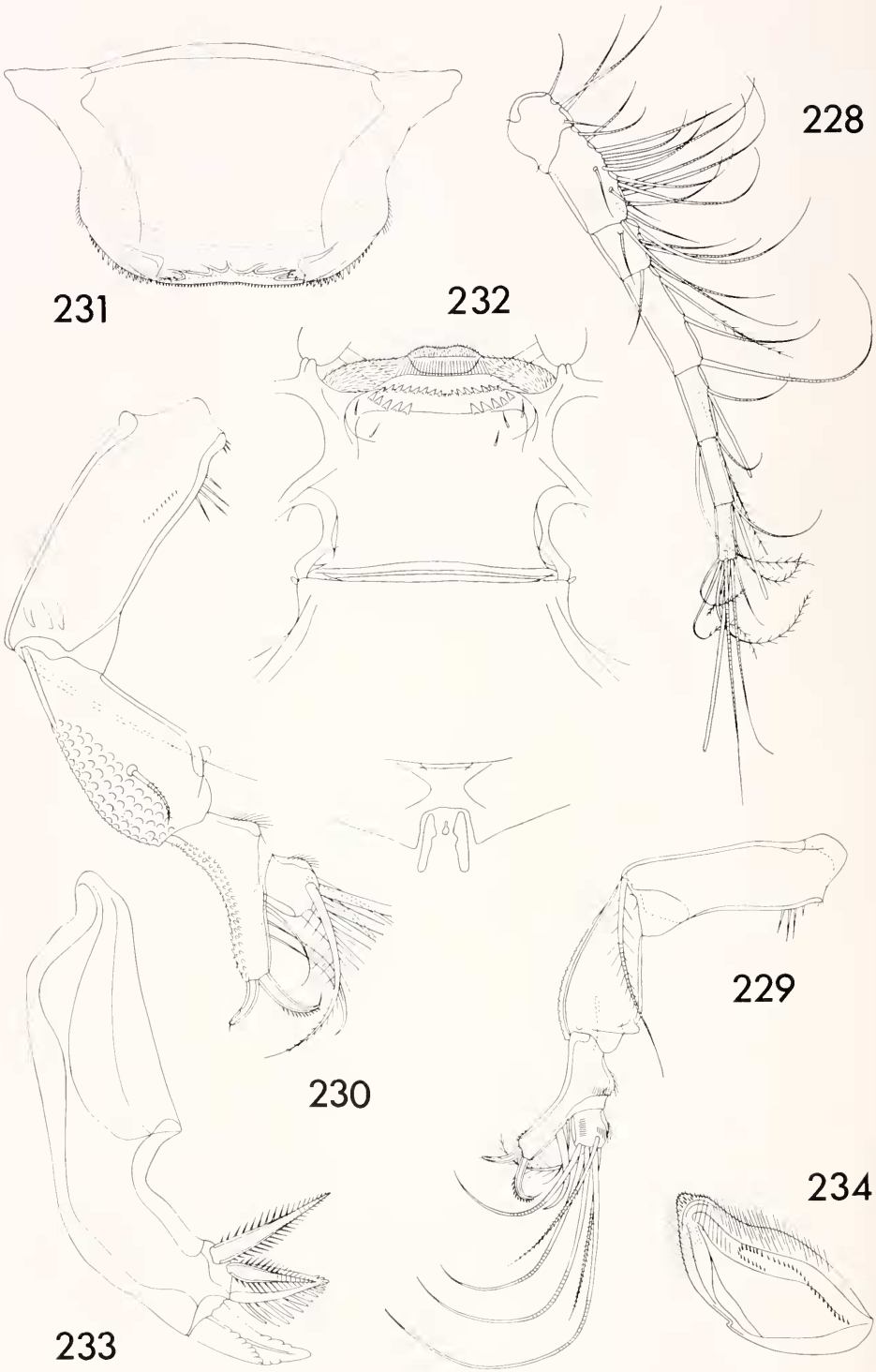
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Plate XXXIII

Hemicyclops acanthosquillae n. sp., female (continued)

Fig. 228. First antenna, anterodorsal (H).
Fig. 229. Second antenna, anterior (G).
Fig. 230. Second antenna, posterior (D).
Fig. 231. Labrum, ventral (D).
Fig. 232. Metastomal areas and region between maxillipeds and leg 1, ventral (G).
Fig. 233. Mandible, anterior and dorsal (E).
Fig. 234. Paragnath, posterior and ventral (E).

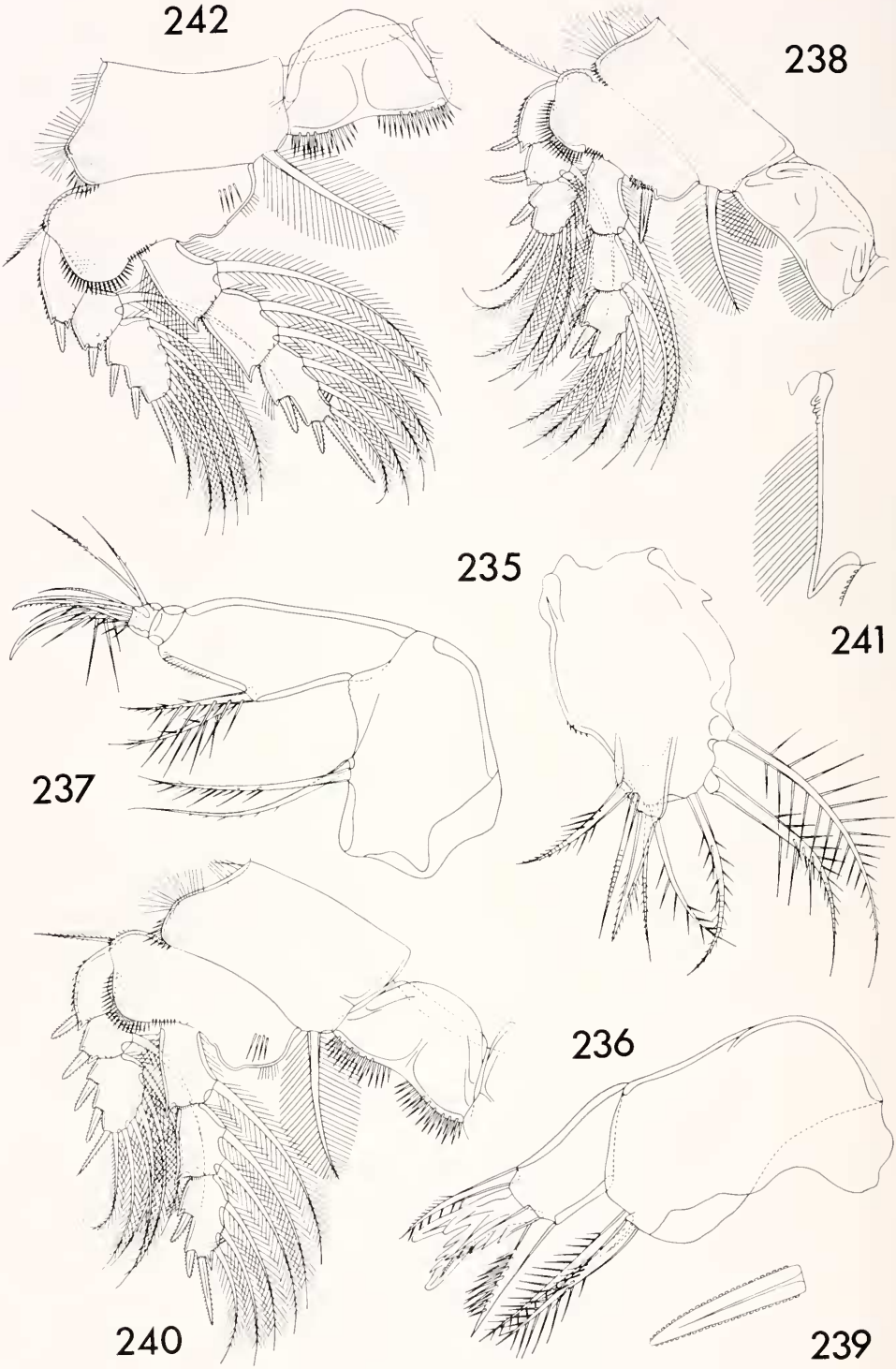
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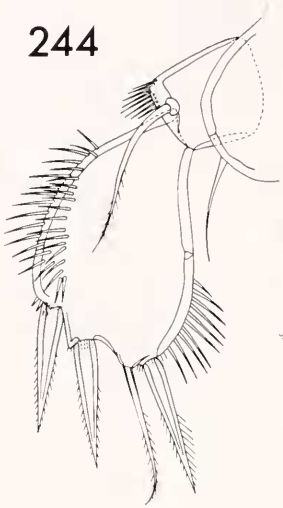
Plate XXXIV

Hemicyclaps acanthosquillae n. sp., female (continued)

Fig. 235. First maxilla, posterior (E).
Fig. 236. Second maxilla, posterior (D).
Fig. 237. Maxilliped, dorsal (D).
Fig. 238. Leg 1, anterior (H).
Fig. 239. Inner spine on basis of leg 1, anterior (E).
Fig. 240. Leg 2, anterior (H).
Fig. 241. Outer edge of second segment of endopod of leg 2, anterior (E).
Fig. 242. Leg 3, anterior (H).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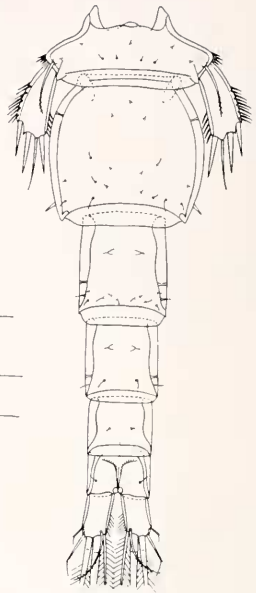
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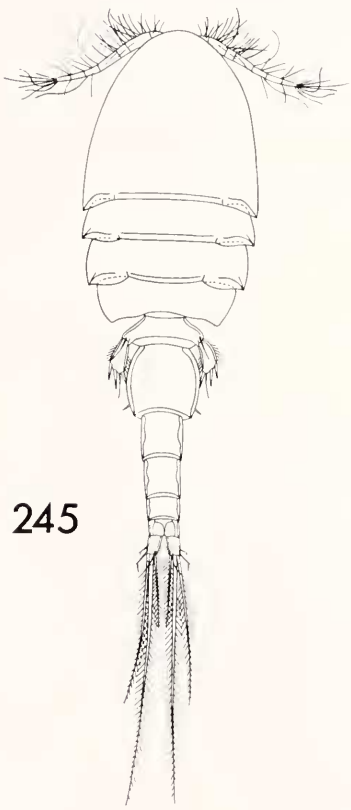
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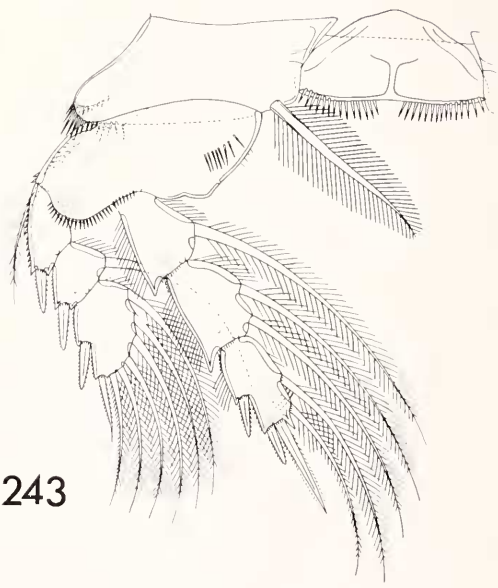
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Plate XXXV

Hemicyclops acanthosauillae n. sp., female (continued)

Fig. 243. Leg 4, onterior (H).
Fig. 244. Leg 5, dorsal (G).

Hemicyclops acanthosquillae n. sp., mole

Fig. 245. Body, dorsal (A).
Fig. 246. Urosome, dorsal (C).
Fig. 247. Portion of segment of leg 5 showing projection, dorsal (E).
Fig. 248. Spermotophore (G).

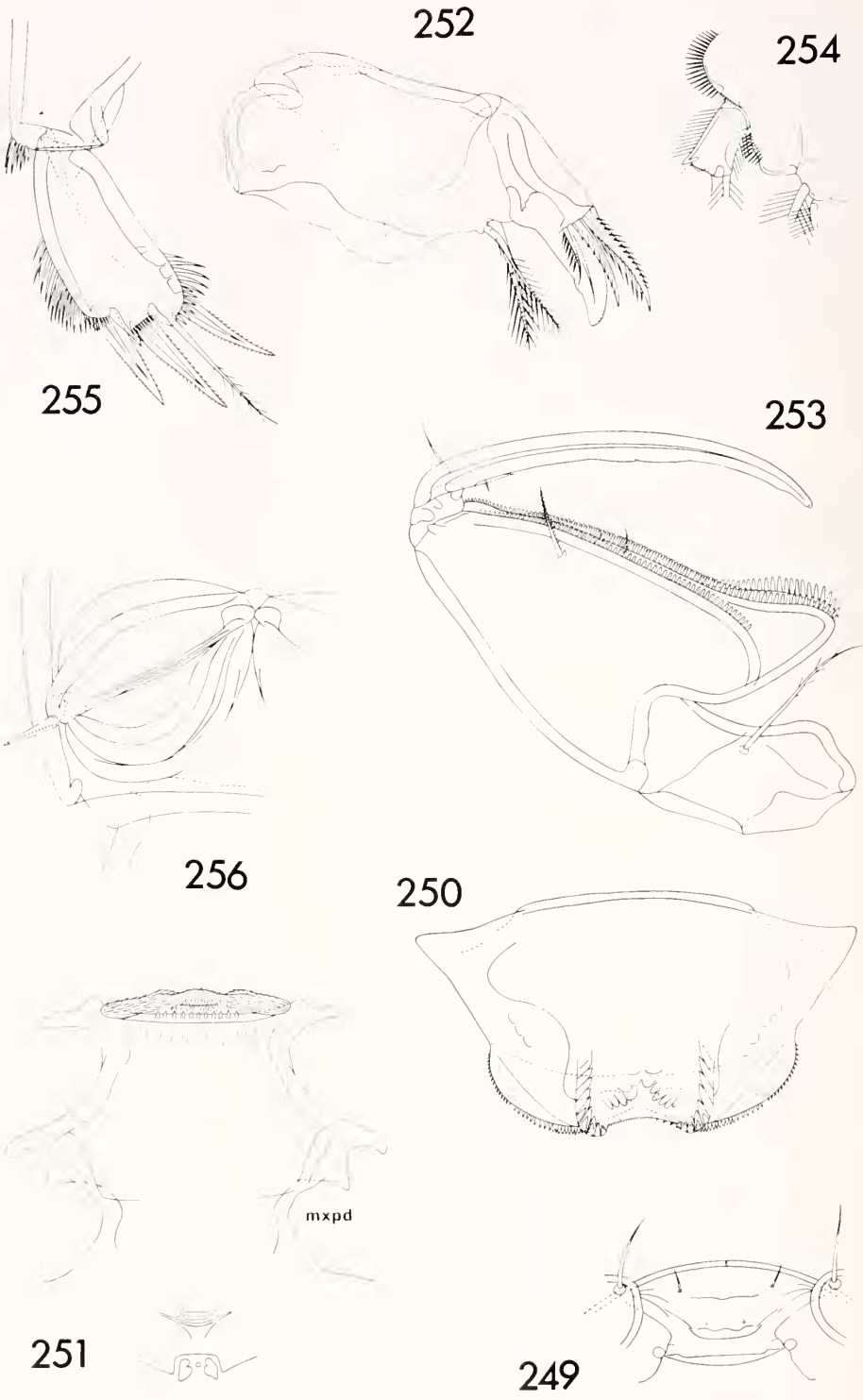
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Plate XXXVI

Hemicyclops acanthasquillae n. sp., male (continued)

Fig. 249. Rostral area, ventral (G).
Fig. 250. Labrum, ventral (D).
Fig. 251. Metastomal areas and region between maxillipeds and leg 1, ventral (H).
Fig. 252. Second maxilla, anterior (G).
Fig. 253. Maxilliped, anterior (G).
Fig. 254. Detail of leg 1, anterior (H).
Fig. 255. Leg 5, ventral (G).
Fig. 256. Leg 6, ventral (G).